NATURE

No. 4641 SATURDAY, OCTOBER 11, 1958 Vol. 182

CONTENTS

	Page
Spiritual Values and World Order	965
Contributions to the Theory of Water Waves. By Dr. M. S. Longuet-Higgins	967
Encyclopædia of Physics. By Dr. E. Bretscher	968
All the Enzymes. By Prof. Britton Chance	969
A Record "Zoological Record". By Dr. Edward Hindle, F.R.S.	970
Synthetic Taxonomy. By Prof. T. G. Tutin	970
Studies in Business Organization. By L. G. Jaeger	971
Archæology of South-East England. By M. C. Burkitt	971
Air Showers of Size Greater than 10^5 Particles. By M. H. Brennan, J. Malos, Dr. D. D. Millar and C. S. Wallace.	973
Radio Aids to Navigation	978
Modern Problems in Friction and Lubrication. By Dr. D. Tabor	980
The Institute of Metals. By Prof. F. C. Thompson	981
Distribution of Proflavin-induced Mutations in the Genetic Fine Structure. By Dr. S. Brenner, Prof. S. Benzer and Mrs. L. Barnett	983
Utopian Education	985
Obituary : Dr. G. R. Bisby. By Dr. G. C. Ainsworth	987
News and Views	987
Scientists in the Public Service in Britain	991
Occupational Psychology. By J. G. McComisky	993
Analytical Chemistry, Pharmacy and Medicine	995
Form and Function in the Mollusca. By Prof. C. M. Yonge, C.B.E., F.R.S.	996
Time-Span of Discretion in Job Analysis	998
Evidence for Permeability Minima in Low-Pressure Gas Flow through Porous Media. By Dr. D. M. Grove and M. G. Ford	999
Condensation produced by Ultra-violet Light. By Dr. A. J. Barnard and W. L. Mouton	1001
Direct Recording of Fluorescence Excitation Spectra. By Dr. C. A. Parker	1002

Letters to the Editors :

Metamidium : a New Trypanocidal Drug.—W. R. Wragg, K. Washbourn, K. N. Brown and J. Hill 1005
A Rate-Governing Reaction of Protein Synthesis.—Henry Borsook 1006
Inhibition of Dextransucrase by Excess Substrate.—W. Brock Neely 1007
Determination of the Mass Thickness of Cell Membranes from their Electron Micrographs.—M. L. De and P. Sadhukhan 1008
A New Method of tracking Artificial Earth Satellites.—A. P. Willmore 1008
Scale Height of the Upper Atmosphere.—C. H. Bosanquet 1010
Thermo-electric Observations on Grey Selenium.—J. I. Carasso and R. W. Pittman 1011
New Supersonic Phenomena.—Dr. Wladimir Philippoff 1011
Crystal Structure of β-Wollastonite.—Miss Joan Tolliday 1012
Tetrahedral Co-ordination in Ni(II).—Dr. Leonard I. Katzin 1013
Production of Methane from Carbon.—Dr. J. D. Blackwood 1014
Paper as a Carrier of Chromium Sesquioxide.—J. L. Corbett, J. F. D. Greenhalgh and A. P. MacDonald 1014
The Problem of Negative Anharmonicity and the Nature of the Hydrogen Bond in Potassium Hydrogen Fluoride.—R. Blinc 1016
Synthesis and Structure of 2,6-Dihalo-Benzenone-Indophenylacetate and Benzenone-Indo-3',5'-Dihalo-Phenylacetate.—C. de Borst, F. N. Hooge and G. J. Arkenbout 1017
Transport of Vitamin A Ester in Rat Serum.—C. F. Garbers 1018
Effect of Diet on Imidazole Compounds and Creatine in Chinook Salmon.—Dr. A. Lukton 1019
Replacement of Adrenaline and Noradrenaline in the Innervated and Denervated Adrenal Gland of the Rat, following Depletion with Reserpine.—B. A. Callingham and Dr. Monica Mann 1020
Mast Cell and Histamine in Rat Anaphylaxis : the Effect of *Haemophilus pertussis*.—I. Mota 1021
Release of Ammonia by Plant Tissues treated with Indole-3-Acetic Acid.—Leonora Reinhold 1022
Presence in Root Tips of a Thermolabile Factor causing the Conversion of Protochlorophyll to a Leuco-Compound.—Z. Hajnowicz 1023
An Observed 'Oxygen Effect' during Gamma-irradiation of Dried Bacterial Spores.—Alan Tallentire 1024
Absence of Pectolytic Enzymes in a Pathogenic Strain of *Fusarium oxysporum f. lycopersici*.—Dr. K. McDonnell 1025
Initial Irradiation Reaction in Mice.—Dr. Harold Blondal 1026
Corneo-Fundal Potential Variations during Light and Dark Adaptation.—Christine Kris 1027
A Water-soluble, Diffusible Pigment produced by a Strain of *Serratia marcescens* (*Chromobacterium prodigiosum*).—Prof. R. P. Williams, W. W. Taylor, D. Hawkins, jun., and I. L. Roth 1028
Serum Protein Variations in Horses.—G. C. Ashton 1029
Fine Structure of the Nuclear Envelope of Carcinoma Cells.—M. De Groodt, Prof. F. Derom, A. Lagasse, Prof. M. Sebruyns and Dr. M. Thiery 1030
Phosphatidyl Serine and Blood Coagulation.—Dr. P. Barkhan, Dr. M. J. Silver, Dr. P. B. da Costa and Dr. L. M. Tocantins 1031
Standard Atmospheres in Respiratory Physiology.—Dr. R. H. Kay 1032
The Enigmatical Trematode "*Dictyocotyle coelioca*".—Dr. Ben Dawes and Dr. Ivor Griffiths 1033
Tubule Formation in Rat Brains by Monkey Kidney Cells previously grown *in vitro*.—Prof. M. Michael Sigel, Thomas M. Scotti, Martha A. Wryk and Mantley Dorsey, jun. 1034
Adaptive Muscular 'Allomorphism'.—Einar Helander 1035
Salt Requirements in the Tropics during Summer.—Surgeon Lieut. Commander Mangal Sain Malhotra 1036

DIFCO *microbiological reagents and media*

Antisera and Antigens

Enteropathogenic Coli — Klebsiella

Salmonella — Shigella

Brucella — Leptospira — Streptococci

★

C Protein Antiserum and Standard

★

Infectious Mononucleosis Antigens and Standards

Over 60 years' experience assures UNIFORMITY · STABILITY · ECONOMY

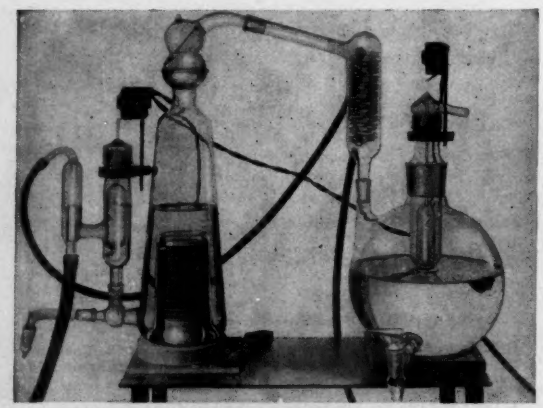
Difco Laboratories

Prompt delivery from U.K. stock. Write for Difco Manual and technical leaflets to the sole agents:

BAIRD & TATLOCK (LONDON) LTD., CHADWELL HEATH, ESSEX, ENGLAND

Branches in London, Manchester and Glasgow *Agents throughout U.K. and all over the world*

TAS/DO.9



This unique water still is in use in a number of research establishments and hospitals where water of the highest purity is essential

PRICE, complete with heater and all electrical equipment 230 volt (a.c. only)—**£25 - 10 - 0**

Inclusive of carriage and packing in U.K.

Obtainable ONLY from

L. V. D. SCORAH, M.Sc.

(Manufacturer of the "SCORAH" Blowpipe)

44 NORTHFIELD ROAD, KINGS NORTON, BIRMINGHAM, 30. KINGS NORTON 1885

The SCORAH Automatic Electric all glass WATER STILL (patented)

Automatic Can be left on without attention. Heater current cuts off if water supply is interrupted, or inadequate or forgotten. When receiver (5 litres capacity) is full, current cuts off. When distilled water is drawn from receiver, the still resumes operation until receiver is refilled.

Purity Electrostatically charged condenser droplets can pick up fumes, dust and air-borne organisms from the laboratory atmosphere. The design of the receiver vessel ensures absence of such contamination.

Efficiency Heater of Scorah design and manufacture, consumption 1,700 watts, output 2.4 litres per hour (the full theoretical yield). Cost 3½d. per gallon at 1d. per unit.

Safety The heating element is out of contact with the feed water, thus eliminating danger from "live" water supply or electrolytic effects or "burn out".

Assembly No retort stands or clamps are required. The 2½-in. diameter ball joint gives a strainless set-up. Outlet cap on boiler for quick periodical drain-off of sediment. The still may be installed on a shelf or platform about 1 ft. above bench level near a sink and enclosed in a transparent plastic cover to keep out dust.
Phoenix heat-resisting glass. Interchangeable ground glass joints.

SPIRITUAL VALUES AND WORLD ORDER

So far as men of science are concerned, the Lambeth Conference report* follows much the same pattern as its immediate predecessor. The bulk of the report is concerned with topics which are not the immediate concern of scientists, as such, though they will note the resolution which gratefully acknowledges the work of scientists in increasing man's knowledge of the universe. Many, no doubt, will welcome the summons to Christian people which follows "to learn reverently from every new disclosure of truth", as they will, too, the passage in the Encyclical Letter which admits that, "though the scientific and technological achievements of our age have encouraged a spirit of self-confidence which feels no need for God, yet underneath there is a spiritual emptiness"—and some will agree with the concluding words, "which only a faith in the reconciling love of God can satisfy".

This point of view is presented more fully in a passage in the report of the Committee on the Authority and Message of the Bible, in which, recognizing that the conflict which once existed between religion and science, through the misuse on both sides of their respective roles, has largely changed its ground, the Committee holds that a neutrality in which each ignores the other would be disastrous, and affirms its conviction that all knowledge comes from God and is to be reverenced as his gift. In all the discoveries of the sciences, God has a purpose that they may be used to reflect his glory in the world, and the Christian Church is summoned to learn from all new disclosures of truth. In that spirit the scientist should respect the further obligation of the Church to proclaim her message of the righteous God.

This outlook and temper are worth noting, because two sections of the report are concerned with problems with which men of science, as such, are equally concerned, and also because the solution of those problems may well lie, in part, in a harmonious partnership or understanding between the scientist and the Christian Church. First are the problems involved in reconciliation of the conflicts between and within nations, and second are the group of problems centring around the family in contemporary society. On the first, there is a dignified condemnation of racial discrimination in the resolutions and a survey of the racial problem, much of which, such as its condemnation of *apartheid*, is in keeping with representations which scientists, university teachers and administrators and others have made in a particular context, such as the autonomy of the South African universities. There are sensible references to industrialization and to what is required to eliminate industrial conflict and restore a lost sense of community and promote real freedom of communication and its maintenance. There are comments, too, on the rights of men and nations, and the sharing of material resources, which express an attitude of mind freely shared by men of science; and the concluding section of this Committee's report, in which political conflicts are considered, merits close attention, because it poses a problem of action and of impartiality with which scientists are themselves familiar and which lies at the root of any attempt to apply scientific or technological knowledge impartially and objectively in public affairs.

Outstanding, however, in this field is the problem of peace, and especially the issues raised by the existence of nuclear and thermonuclear weapons. No attempt is made to conceal the existence of a division of opinion in the Conference itself, such as would be found in almost any representative body, Christian or non-Christian, regarding the use of nuclear weapons. The Encyclical Letter admits that while the use of such weapons is repugnant to the Christian conscience, and some regard their use in any circumstances as morally indefensible, others hold that as long as such weapons exist there are circumstances in which to use them might be preferable to political enslavement. The Conference believed that the abolition of nuclear weapons of indiscriminate effect and destructive power by international agreement is an essential step towards the abolition of war itself, and its resolution on modern warfare and Christian responsibility calls upon Christians to press through their governments, as a matter of utmost urgency, for the abolition by international agreement of nuclear bombs and other weapons of similar indiscriminate destructive power, and urges governments to accept such limitations of their own sovereignty as effective control demands.

The resolution further urges the governments of the leading nations of the world to devote their utmost efforts at once to framing a comprehensive international disarmament treaty, which shall also provide for the progressive reduction of armed forces and conventional armaments to the minimum necessary for the maintenance of internal security and the fulfilment of the obligations of States to maintain peace and security in accordance with the Charter of the United Nations. A further resolution, affirming the need for strengthening the United Nations, urges to that end that serious consideration be given to the revision of the Charter, to the more effective use of, and respect for, the existing processes of international justice, and to the creation of adequate means for enforcing its decisions. The

* The Lambeth Conference 1958. The Encyclical Letter from the Bishops together with the Resolutions and Reports. Pp. 171. (London: S.P.C.K.; Greenwich, Conn.: Seabury Press, 1958.) 7s. 6d.

resolution likewise commends whole-heartedly the work done under the ægis of the United Nations, whereby the skills and resources of member nations are made available for the benefit of the whole of humanity.

This appeal for more enlightened support for the United Nations, so that it may become a more effective instrument of world peace and of that free co-operation between nations which is the condition of world order, is supported by a statement on peace and by a well-argued passage on conflicts between nations in the report of the Committee, over which Archbishop Joost de Blank of Cape Town presided. The statement lays its stress on the price which has to be paid for the establishment of peace and the creation of a world order of freedom and justice on which true peace can be based. It emphasizes that sacrifices will be demanded—of nations and of individuals: the foregoing of policies of self-interest which deny the interests of others, and the acceptance of at least some limitations of national sovereignty. Moreover, it is a long-term process: not in a day can trust replace mistrust, and partnership replace selfishness. Disagreements, rivalries and misunderstanding will long remain between nations and individuals, and a strenuous effort of mind and will is demanded of men if they are to understand and overcome, with a new urgency, the practical problems which divide the human family.

Much of this has been said, with increasing force, over the past thirty years, by scientists themselves as well as by others. The report enters also into the practical details which arise in the reconciliation of a world at so many widely differing stages of development, with such widely varying conceptions of law, freedom and standards of living. None the less, points are made which are worth re-emphasizing, and there is much to support the validity of the Committee's argument in one particular respect of the situation. Accepting the validity of the scientific method in its own domain and recognizing the wide range of benefits which science has brought to mankind, the Committee points out that science itself does not and cannot provide the key to the right use of the immense and rapidly increasing power it has placed in men's hands. The physical power of nuclear fission and the possibilities of psychological or genetic change are as much a threat to man's future life in this world as they are a potential source of great advantage to humanity.

Now that the world has been so progressively conditioned by a scientific climate of opinion as well as profoundly affected by the dazzling material achievements of science and technology, people have come to look upon any knowledge other than that obtained by scientific method as suspect. That is one reason for welcoming this report and the spirit in which it is written. It needs no more than the most cursory review of the achievements—and failures—of the United Nations to reveal how inadequate in international affairs is a scientific approach by itself. Something much more is required than the action that rational inquiry by itself may indicate, and whether or not individual scientists can share the hope of spiritual power in the task which this report might inspire, all men of goodwill should rejoice to welcome any co-operation that promises to assist the long slow task of educating public opinion, the removal of misunderstanding and distrust, and the encouragement of a forward-looking mind and readiness to discard old prejudices and try new ways. There should be a wholehearted response when the Christian Church seeks means whereby it can consult with scientists and political leaders about the many problems of ethics and conscience which may arise from the discovery and development of nuclear fission and fusion.

That in some of these fields scientists do not yet know the answers to the scientific and technical problems should make them the readier to co-operate with all who are open-minded and prepared to face changing situations without prejudice. Moreover, it must be admitted that we cannot even say whether a democratic society can establish and maintain world order. If indeed democracy, as we know it in the West, is to succeed in that task, the high moral and intellectual qualities which it demands of its citizens will require a much more effective system of public education than we have yet known in Britain, and moral and spiritual forces such as, it may be, only a religious faith can supply. To that task of education the Christian Church as well as science may well have decisive elements to contribute; nor need we be too pessimistic, in the perspective of time, if we look back merely far enough to visualize the chaos out of which the modern edifice of science has arisen in the past four centuries.

Already, indeed, the attempt to learn through the mistakes and early experience of both the League of Nations and the United Nations is well under way. When the American Bar Association met in London in July 1957, Mr. Herbert Brownell appealed deliberately for a system of law for the nations of the world, and visualized Anglo-American co-operation in developing the law of the nations so as to bind the countries of the world into solemn voluntary pacts, in contrast to unilateral exploitation by strong Powers. It is not, however, solely among the greater Powers that respect for law has to be fostered and the unilateral repudiation of agreements and contracts discouraged; and even here the existence of widely differing standards of value, of civilization and of ways of thought may at times make progress painfully slow. Nevertheless, it is encouraging to see that over the five years, 1951–56, with a grant from the Ford Foundation, Grenville Clark and Louis B. Sohn, with much assistance and comment from others, have worked out a comprehensive and detailed plan for the revision of the Charter of the United Nations*.

This plan, which has been issued this year by the President and Fellows of Harvard College, under the title "World Peace through World Law", and

* World Peace through World Law. By Grenville Clark and Prof. Louis B. Sohn. Pp. xxxvi+540. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1958.) 7.50 dollars; 60s.

dedicated "to all those who seek the rule of law in world affairs", aims, therefore, at the promotion of the maintenance of world peace; but its immediate purpose is to contribute material for the world-wide discussions which must precede the establishment of truly effective institutions to prevent war. Its fundamental premise is that there can be no peace without world law, in the sense of law capable of enforcement as distinct from mere exhortation and injunctions, for the enforcement of which there is no effective machinery. It embodies also the conception that peace cannot be ensured by a continuous arms race, or by an indefinite balance of terror or diplomatic manœuvre, but only by the acceptance of institutions corresponding in the world field to those which maintain law and order in local communities and nations.

These premises, on which are based a set of definite and interrelated proposals to strengthen the United Nations through the establishment of such legislative, executive and judicial institutions as are necessary to maintain world order under enforceable world law, are reflected in the comments of the Lambeth Conference Committee's report on the reconciliation of conflicts; and, as has already been suggested, the forward outlook which characterizes the report should make it easier for the scientist and the Christian churchman to work together in a task which is as vital to the progress of science as it is to the preservation of mankind. It could not be claimed that the report, or for that matter the plan which Grenville Clark and L. B. Sohn advance, is notably freer from vague thinking than most public discussions of the organization of world order, and some of the premises may be unrealistic and open to challenge. At least, however, the dynamic nature of the situation is clearly grasped, and the report and the recommendations are pervaded by a sense that the solution of our dilemma is not to be found in a stable or static society but in a dynamic position of balance or relative security.

Perhaps even more striking evidence of this open-minded and developing outlook—it is not new, for it occurs in the previous Lambeth Conference report of ten years ago—is to be found in the report of the Conference Committee which dealt with the family in contemporary society. That report, which has been described as the great liberal achievement of the Conference, raises issues other than those of peace and war, of nuclear disarmament, racial reconciliation and the co-operation of Christian and scientist; but it is cited here as conclusive evidence of the growth of common ground over the past decade, and of the extent to which the Christian Church is approaching the problems of the modern world in the spirit characteristic of the scientist in his quest for truth. Even those who cannot accept, at least in its entirety, the thought and conclusions that characterize a Christian assembly may well be glad to recognize the powerful support from such a quarter for policies and causes which they have themselves at heart, and which without spiritual and moral support are ever less and less likely to be attained.

CONTRIBUTIONS TO THE THEORY OF WATER WAVES

Water-Waves

The Mathematical Theory with Applications. By J. J. Stoker. (Pure and Applied Mathematics: a Series of Texts and Monographs, Vol. 4.) Pp. xxviii+567. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 12 dollars.

DURING and since the Second World War the study of water waves has been pursued with increasing interest both for its own sake and for its numerous applications in oceanography, coastal engineering and ship-building design. Prof. J. J. Stoker and his colleagues at New York University have made many theoretical contributions, and in this book an attempt has been made to combine them into a logical unity.

The first section of the book is introductory; there is a chapter deriving the basic equations for non-viscous, irrotational flow, and the boundary conditions for gravity waves. The conditions at the free surface are non-linear, and the author describes the two standard methods of approximation: the small-amplitude approximation, in which expansions are in powers of the ratio (wave-height/wave-length); and the shallow-water approximation, in which expansions depend upon the parameter (mean depth/l), where l is a typical horizontal length (not necessarily the wave-length). Parts 2 and 3 of the book which follow are devoted to solutions with the small-amplitude approximation and with the shallow-water approximation respectively.

Among the topics discussed in Part 2 are free and forced oscillations in water of uniform depth, waves on sloping beaches of constant gradient, and waves started from rest by a sudden impulse; also the pattern of waves caused by a moving point-pulse in two or three dimensions (the latter being Kelvin's ship-wave pattern). The problem of the diffraction of waves around a vertical wedge is also solved. The assumption of small amplitude for the waves, and of irrotational motion, permits the use of a linearized potential theory. Particularly in the problem of waves on a sloping beach, the author uses complex-variable theory to great advantage. Part 2 ends with a chapter on a linearized theory of ship motion, assuming a thin hull-shape.

Thus far the mathematical treatment is of a high standard of interest, and though experimental evidence is lacking no reader will have difficulty in accepting the conclusions (for waves of sufficiently small amplitude). However, the first chapter of Part 3, which deals with waves in shallow water, is somewhat more controversial. The author applies the method of characteristic curves (also used in gas dynamics) to the propagation of waves in water of constant or slowly changing depth. The theory is approximate and is only valid so long as the vertical acceleration can be neglected. Thus the approximation is scarcely likely to hold for waves near the point of breaking. Indeed, the whole region of validity of this approximation needs further examination. Also included in this chapter are a new treatment of the solitary wave theory, and an application of the shallow-water theory to gravity waves in the atmosphere.

The remaining chapter of Part 3 contains a study of roll waves, assuming an empirical law of turbulent

friction. The theory has been applied with some success to flood waves in the Mississippi River.

Finally, in Part 4, the author has grouped together two pieces of work under the heading "problems in which free surface conditions are satisfied exactly". The first of these is a version of Levi-Civita's proof of the existence of permanent waves (of sufficiently small amplitude) in deep water. The proof is slightly shorter than Levi-Civita's, but relies on more sophisticated techniques in function-theory. The other problem treated in this chapter is the flow resulting from a breaking dam (strictly speaking only the initial flow, for the solution is carried only as far as the terms in t^2).

For lack of space, many interesting and important topics have had to be omitted. For example, there is no mention of surface-tension waves, internal waves, or standing waves of finite amplitude, and with the exception of Chapter 11 the interesting effects of viscosity are completely neglected. Other developments, such as the statistical theory of sea waves and the theory of cnoidal waves (which really fills the gap between the small-amplitude theory and the shallow-water theory), are mentioned only in passing. Nevertheless, in those subjects that are discussed more thoroughly the reader will find many useful references.

The book as a whole is written from the point of view of the mathematician; greater attention to the physics (as for example in the case of breaking waves) would have been desirable as well as, more generally, a closer comparison with observation. Nevertheless, Prof. Stoker has produced, if not a classic, yet a book of considerable interest in a rapidly expanding field.

M. S. Longuet-Higgins

ENCYCLOPÆDIA OF PHYSICS

Handbuch der Physik

Herausgegeben von S. Flügge. Band 40: Kernreaktionen I. Pp. vi+553. 128 D.M. Band 42: Kernreaktionen III. Pp. vii+626. 135 D.M. (Berlin: Springer-Verlag, 1957.)

In Volume 40 a general account of nuclear reactions, levels and spectra by Prof. W. E. Burcham covers the light nuclei up to mass 40, while the same topics are dealt with for heavy nuclei by Dr. B. B. Kinsey. Almost all the experimental work referred to in these two chapters falls into the energy region below 50 MeV. The high-energy region of nuclear reactions is surveyed by Dr. A. Wattenberg, while the basic nucleon–nucleon interactions are treated in their theoretical and experimental aspects in Volume 39 of the series by Drs. L. Hulthen and M. Sugawara. Prof. J. Rainwater has contributed a section on resonance processes by neutrons. The general theory on nuclear reactions by G. Breit and collaborators can be found in Volume 41 (Nuclear Reactions II).

Prof. Burcham writes with his customary lucidity and erudition, about 20 pages of an excellent introduction to the current theories summarizing nucleon–nucleon interactions, models, coupling schemes and the general theoretical features of reactions; this is followed by a chapter on experimental methods for studying energy-levels, always giving just enough theoretical background to produce a happy blend useful to the consultants of this "Handbuch". Dr. Kinsey's contribution comprises a monumental and excellent monograph on nuclear reactions of the more complex nuclei and their levels and spectra. It is well written and, most important, the material is critically surveyed, an onerous task in view of the enormous literature. In view of the discriminating approach it is stimulating, suggestive of ideas and will no doubt be much consulted by research physicists. It is not quite clear to the reviewer why the editor included an article on resonance processes by neutrons, since this subject-matter could have been included in Dr. Kinsey's and Prof. Burcham's article. (See Fig. 33 and Fig. 15 of Dr. Kinsey.) As it is, Dr. Rainwater's section is authoritative, though not too well balanced, dealing almost exclusively with total cross-sections. There are too many graphs of a similar character and three derivations of the Breit–Wigner formula. The last of these could have been left to Volume 41 in "Nuclear Reactions II", where it will presumably be found again in Prof. Breit's article. Dr. Wattenberg's section on high-energy processes is a useful summary for a research physicist working in the field. The article contains a chapter on mesons and their interaction with nuclei, though meson physics proper is dealt with in Volume 43.

The contents of Volume 42 are made up of the following contributions: "Nuclear Isomerism" by Dr. D. E. Alburger (Brookhaven National Laboratory); "Alpha Radioactivity" by Prof. I. Perlman and J. O. Rasmussen (University of California); "The Transuranium Elements" by Dr. E. K. Hyde and Prof. G. T. Seaborg (University of California); "The Nuclear Photoeffect" by Dr. G. R. Bishop (University of Oxford) and R. Wilson (Harvard University); "Angular Correlations" by Prof. S. Devons and L. J. B. Goldfarb (University of Manchester); "Oriented Nuclei" by Dr. R. J. Blin-Stoyle and Dr. M. A. Grace (University of Oxford).

It is a pleasure to be able to say that all the articles in this volume are of the highest standard scientifically and didactically. To have been able to convince the participating authors to undertake such an arduous task confers great merit on to the editor. Who would have been able to cover the two chapters on alpha activity and transuranium elements better than the members of the Berkeley Radiation Laboratory, where so much of the research reported has been done under the inspiring leadership of Prof. G. T. Seaborg. The progress in this field is a spectacular monument to the benefits to science resulting from the development of reactors and accelerators. Forecasting the properties, chemical and physical, from systematics has reached a high state of perfection, and the progress in our ideas on nuclear models stands out clearly, the overwhelming evidence being due to artificially produced nuclei.

Dr. Alburger's article on nuclear isomerism is a model of clear exposition, full of useful information on theory and practice, so that not only the specialist can, in fact, use it. "Angular Correlations," by Prof. Devons and Dr. Goldfarb, covers in a uniform notation all the information one could desire in an excellent monograph (pp. 362–554). The mathematical treatment is, from necessity, abstract, but the results are aptly illustrated by correlation experiments drawn from the literature. This contribution illustrates the degree of theoretical knowledge expected from the experimentalist who embarks on a study of nuclear transition and the character assignment of levels. It is a pity that the teaching in the universities in Britain does not as a rule prepare the student particularly well in a field of such impor-

tance. "Oriented Nuclei," by R. J. Blin-Stoyle and M. A. Grace, offers a fine summary of a field where a great deal of important work can still be done. The chapter on the nuclear photoeffect (G. R. Bishop and R. Wilson) presents an able and complete survey of the field covering the experimental methods and the theoretical background for an adequate interpretation of the results. When the physicists have succeeded in producing monochromatic gamma-rays from the presently much-used continuous spectrum we can expect a great deal of further progress. The large intensities of the high-current accelerators hold much hope that this will be done soon.

On the whole, one can say that the field of experiments in nuclear physics and their interpretation in terms of theory have been well covered in Volumes 40 and 42, with the exception of beta decay and the fission process, which are to be found in Volume 41.

The references all through both volumes refer to publications which appeared roughly during 1950–56. Some reports on fields in rapid progress are therefore no longer completely up to date, such as the section on neutron resonance processes, in spite of an appendix. The standard of the "Handbuch" is well up to that of its predecessor published during the years 1926–29 by Julius Springer. It is remarkably free from obvious errors; but there is one misunderstanding: the strength function Γ_n^0/D does not refer to a single resonance but to an average over many resonances (Volume 40, p. 551). The absence of an author index is for some purposes regrettable. The value of this unique encyclopædia to the research physicist and university teacher is very great indeed.

E. Bretscher

ALL THE ENZYMES

Enzymes

By Dr. Malcolm Dixon and Dr. Edwin C. Webb. Pp. xviii+782 (12 plates). (London: Longmans, Green and Co., Ltd.; New York: Academic Press, Inc., 1958.) 90*s*. net.

THIS is one of the finest books that has appeared on the topic of enzymes. It is probably the first to maintain properly the tradition set by J. B. S. Haldane's "Enzymes" of 1930. Dixon and Webb proceed from that definitive treatment of enzymes with adequate mathematical presentation of enzyme kinetics and with concise discussions of properties of enzymes, their isolation, their specificity, their reaction mechanisms, etc., so that both students and research workers can obtain a comprehensive picture of the current status of our knowledge of enzyme action. In these days of 'brainstorming' and 'team' approaches, it is most encouraging to see the excellent and deliberate work of these highly qualified scholars, proving that, in their own terms, "the more old-fashioned type of book has advantages in continuity and consistency of treatment". This volume will surely be the standard reference work on enzymes for a number of years to come and will serve as a point of departure for many monographs on specialized topics in enzymology.

In addition to their extensive integration and categorization of the properties of enzymes, the authors have made a number of attempts to standardize various aspects of enzyme nomenclature and definitions of activities. While not all will agree with some of the classifications of enzymes, coenzymes, and cofactors, the proposals that have been put forward in this volume are logical and adequately documented. Since international commissions are now considering nomenclature and other aspects of enzymology, the material of this book will be extremely useful as a basis for decisions on controversial points, especially since the authors have attempted to maintain an objective point of view on these subjects.

The text is sufficiently extensive (670 pages) to deal comprehensively with the topic of enzymology, but because it is short, irrelevant and trivial aspects have of necessity been eliminated. It opens with a striking "'Atlas' of Crystalline Enzymes", which contains microphotographs of available enzyme crystals. In the second chapter, "Enzyme Techniques," the authors state the basic principles of enzymology in a language and form that can easily be understood by the student. This presentation continues through methods of enzyme isolation. Interesting discussions on "criteria of purity" of enzymes and "pitfalls in working with pure enzymes" are given. The book then launches into an extensive chapter on enzyme kinetics which can also be readily understood by the student. The plan of treatment follows that of J. B. S. Haldane and fortunately retains his terminology. Useful equations on the effects of enzyme and substrate concentrations, *p*H, temperature, inhibitors, etc., are included. The reviewer would like to note in passing that this volume may well mark the high-tide in the use of algebra to obtain analytic solutions for equations of enzyme action: analogue and digital computers are advanced to a point where they may be used routinely in further mathematical investigations of enzyme systems.

The fifth chapter contains a magnificent 92-page table in which the enzymes are divided into two main categories: hydrolysing enzymes (221 entries) and transferring enzymes (359 entries). Each enzyme is assigned a number which is referred to uniformly throughout the book. Again, some degree of arbitrariness has been necessary to categorize enzymes in this manner. (It was pointed out to the reviewer that enzyme 173 should be re-located near enzyme 215.) The sixth chapter discusses enzyme specificity and includes detailed data on peptidases and glucose oxidase. The reviewer makes note of the fact that definitive studies of enzyme specificity require measurements over very wide ranges of reaction velocity constants (about 10^6).

In Chapter 7, "Enzyme Mechanisms," a number of current theories on this subject are discussed in detail. However, some of the pages devoted to chain reaction theories might have been better spent on mechanisms for which more experimental data are available. The eighth chapter, "Enzyme Inhibitors," is very complete in its treatment of isolated enzymes. The fact that the book is not intended to cover inhibitors of metabolism leads to an abbreviated treatment of inhibitors in this class. In the ninth chapter, "Enzyme Cofactors," the case for retaining the coenzyme nomenclature (Co-I, etc.) in place of DPNH, etc., is made by the authors. The classification of cytochrome *c* as a carrier and not as an enzyme will be found difficult to apply to a sequence of cytochromes, as in the respiratory chain. Also, the omission of cytochrome *a* from the respiratory chain and the acceptance of evidence for a 'shuttle' and a 'transit time' of cytochrome *c* between cytoplasmic reductases and mitochondrial oxidase may require some reconsideration. The treatment of cytochromes is somewhat below the high standards of the remainder of

the book, but this may be caused by doubts in the authors' minds as to the degree to which these enzymes afford a complete explanation of cellular respiration (cf. p. 423). Also, the list of cytochrome oxidases (p. 207) needs some amendment: cytochrome a_1 is not specified and a photo-oxidase of undetermined nature is included.

Chapters 12 and 13 on enzyme systems and enzyme biology, respectively, propose to bridge the gap between the the action of isolated enzyme systems and enzyme functions in the living cell. A 32-page table of enzyme systems represents a useful attempt to achieve an integrated treatment of such systems. As may be expected, the scope of these chapters is somewhat restricted because no serious attempt is made to give a comprehensive review of metabolism as a whole.

The book concludes with a complete list of symbols and abbreviations and a most extensive bibliography, conveniently arranged in alphabetical order and containing 2,353 references. It also contains a detailed and effective index.

This book will be widely used by the student and the research worker; it is easy to understand, easy to use, and authoritative. Britton Chance

A RECORD "ZOOLOGICAL RECORD"

The Zoological Record, Vol. 92

Being the Records of Zoological Literature relating chiefly to the year 1955. Edited by G. Burder Stratton. Pp. vi+1852. (London: Zoological Society of London, 1958.) 160*s*.

THE present volume relating mainly to zoological literature of 1955 is an indication of the increasing amount of research work in the subject, for this is the largest volume in the history of the "Record". All the sections have now been brought up to date with the exception of Trilobita, which only includes literature for 1954. The delay of about two and a half years in the appearance of the "Record" is surprisingly short in view of the difficulties of publication, and the editors and recorders deserve the thanks of zoologists throughout the world for their invaluable service. It should be emphasized that the individual sections are issued separately as soon as they are ready for publication, so that these are available at a much earlier date than the complete volume. The sections Aves, Comprehensive Zoology and Porifera, for example, were issued in November 1956, less than a year after the literature to which they refer, and most sections were available in 1957.

There is very little change in the relative size of each section, Insecta still heading the list with 535 pages compared with 546 the previous year; then Mammalia, 129 pages, closely followed by Mollusca, Vermes, Protozoa, Arachnida and Aves; and in descending order, Reptilia, Pisces, Crustacea, Amphibia, Trilobita, Coelenterata, Echinoderma, Brachiopoda, Comprehensive Zoology, Protochordata, Bryozoa and Porifera.

A total of 1,963 new generic and subgeneric names is recorded, a drop of 450 on the previous year. It is of interest to compare the numbers in the various groups, which correspond more or less with the size of each section so far as invertebrates are concerned. In the vertebrates, however, Aves, Amphibia and Reptilia with only twelve, four and fifteen new names, respectively, would seem to be reaching a settled nomenclature, but in Mammalia there is the surprisingly high total of fifty-six new names, and in Pisces seventy-one.

The difficulty of inventing new names is well recognized, but the present list in many instances contains such involved and clumsy terminology as to arouse a certain regret that simpler and rather more elegant names could not have been devised.

The "Zoological Record" owed much to the work of Dr. Malcolm Smith, whose death occurred recently. He was sectional recorder of Reptilia and Amphibia for seventeen years and editor from 1938 until 1949, including the very difficult years during the War, when he still managed to maintain the publication of the "Record". Edward Hindle

SYNTHETIC TAXONOMY

The Bladder Campions (*Silene maritima* and *S. vulgaris*)

By E. M. Marsden-Jones and Dr. W. B. Turrill. Pp. vii+378+44 plates. (London: The Ray Society, 1957. Sold by Bernard Quaritch, Ltd.) 30*s*.

THE detailed researches on *Silene maritima* and *S. vulgaris*, begun more than thirty years ago by Dr. Turrill and Mr. Marsden-Jones, are widely known as classics of 'synthetic' taxonomy. Hitherto, the results of these investigations have been available only in a series of thirty-four papers in the *Kew Bulletin*, extending over the years 1928 to 1957, and it has, inevitably, been a matter of considerable time and difficulty to obtain a comprehensive view of the subject. This great volume of work is now brought together, with the addition of previously unpublished data, in a well-illustrated book, a large part of which is occupied by the presentation, in a condensed form, of the evidence on which the general discussion of the last twenty pages is based.

To anyone interested in the wider aspects of taxonomy as revealed by a combination of experimental and 'traditional' methods this book will be invaluable. It shows not only how much can be found out about the history, relationships, ecology, genetics, morphology, anatomy and distribution—in a word the taxonomy—of two common species, but also how much remains to be found out, even after more than thirty years of hard work by two able and experienced investigators.

There remain, of course, large and untouched fields outside the scope of the present study, such as the comparative physiology of the various taxa recognized, but it must be evident to the most casual reader that no plant can be dismissed as common and uninteresting or even ordinary. It speedily becomes obvious on reading this book that any plant can keep a botanist fully occupied for a lifetime and still yield only an approximation to omega taxonomy.

Many years must elapse before knowledge of this kind can be accumulated about all the species of flowering plants, even in such a limited flora as that of the British Isles, but any information about the basis of variation, the kind of breeding-system and the factors which isolate and maintain the distinctness of related taxa has an immediate value to the taxonomist.

It seems, however, that for the foreseeable future we shall have, as the authors point out, to be content with a classification based mainly on the classical criteria of gross morphology, modified in small ways by experimental data. Such a system may indeed prove to be the most convenient all-purpose one in the long run, even should it become possible to make phylogenetic or physiological classifications for special purposes.

T. G. TUTIN

STUDIES IN BUSINESS ORGANIZATION

Business Enterprise

Its Growth and Organization. By Prof. Ronald S. Edwards and Harry Townsend. Pp. xvii+607. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 60*s*. net.

THE authors have produced a book on the growth and organization of business that is at once scholarly and immediately intelligible to the layman; this is no mean achievement. The book is based on a wealth of case material built up over the past twelve years. During that time evening seminars on industrial administration have been held at the London School of Economics, the main feature of each seminar being the discussion of a previously circulated paper written by an industrialist or Civil servant. The incorporation of 'potted' case histories from these papers and elsewhere without making the narrative disjointed has been skilfully done.

The book is divided into four parts dealing respectively with the birth and growth of firms, factors determining the size and specialization of firms, the Government and industry, and the future of industry in Britain. There is a steady and noticeable change of emphasis as one proceeds through the book away from the descriptions, explanations and analyses which dominate Part 1 and towards the exposition of what the authors strongly believe to be good for us, which—necessarily in view of its subject-matter—dominates Part 4. Thus, when we read in Part 3 that, "... the reader should be warned that he is dealing with two authors who believe that every extension of central power should be very amply justified before it is granted, and that the onus of proof should always lie with those who propose centralisation", we are merely receiving confirmation of a suspicion that has been building up over several chapters.

Parts 1 and 2 draw especially heavily on the case material referred to above, which provides numerous examples illustrating the developing theme; each of these Parts has several appendixes comprising papers which have been read to the seminar. Part 3 provides an admirable account of the relations between the Government and industry, and includes excellent chapters on Government organization of industrial research, the location of industry, the steel industry and the organization of nationalized industries.

The dust-jacket tells us that the book is addressed to students of industrial economics and government, and to practising business men. It will be surprising if it does not find favour with a much wider reading public than this. In particular, students of science and technology who intend to go into industry should find it a most worth-while addition to their shelves.

L. G. JAEGER

ARCHÆOLOGY OF SOUTH-EAST ENGLAND

An Archæology of South-East England

By Gordon J. Copley. Pp. 324+28 plates. (London: Phoenix House, Ltd., 1958.) 50*s*. net.

IT is stated on the dust-cover that the information contained in this volume can otherwise be found only in numerous scattered publications, many of them of a specialist nature, and that it is a book unlikely soon to be superseded. With these statements any reviewer must agree. Dr. Copley has studied widely and, so far as the limits of his space allow, has covered the ground of the wide area with which he is concerned. The author of such a work of compilation must of necessity begin by fixing in his mind the sort of public for whom he will be catering. I imagine Dr. Copley has written primarily for the instructed amateur. But the maps and, above all, the gazetteer will be welcomed by the specialist as well.

The work opens with some general chapters dealing with such problems as the amateur in archæology and the natural background. These are followed by chapters on periods—Palæolithic to Middle Ages—and in conclusion there is a study of locality and of place names, a bibliography and a gazetteer. In the period chapters there are distribution maps—necessarily of very small scale—and later in the volume, grouped together, will be found 28 half-tone illustrations. The early chapters depend, to a large extent, on Zeuner's work. He is a good guide, even though everyone does not agree with all he suggests—especially his dating. But for the instructed amateur the opening phases of the book will be found useful. The geo-chronology is, of course, far more complicated than could be dealt with in the short account which space allows, but a generalized picture is given. The Neolithic and Early Metal Age chapters, again within the limits of available space, are excellent. Naturally for the later periods, as so much more evidence has survived, the account has to be more sketchy. But Dr. Copley has managed to see the wood in spite of the trees.

Specialists will welcome the bibliography of local publications. So many local societies publish bulletins nowadays that it becomes difficult even to keep check of their names. In respect of the very valuable gazetteer of sites and finds, one can really only criticize the author for not giving any reference to where the finds were published. He says this could not be done without extending the gazetteer to an inordinate length. But the usefulness of the lists would have been enhanced tenfold if a hieroglyphic had been added to each reference. The hieroglyphics could have been associated with the bibliography. For example, take the "black beauty" from Reculver: palæolithic tools from this place are mentioned by cross-reference under Herne Bay, but no one interested in palæolithic tools from that site can follow up the reference or discover whether they were chance surface finds or the result of systematic excavation and investigation. Should the book run to a second edition it is to be hoped the author will give serious consideration to this very important matter. But it is not on a note of criticism that one wants to conclude. The work is, of its kind, excellent; a wide area is covered, and a good picture given of mankind's existence in the region over a long period of time. The author is to be congratulated.

M. C. BURKITT

Theory of Dielectrics

Dielectric Constant and Dielectric Loss. By Prof. H. Fröhlich. Second edition. (Monographs on the Physics and Chemistry of Materials.) Pp. viii+192. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 30*s*. net.

IT is now about nine years since Prof. Fröhlich's book "Theory of Dielectrics" was first published. It was intended mainly for applied scientists, but was also of great value to those working on the theory of the dielectric constant and its relation to atomic structure. This latter subject (dealt with in Chapter 2) is one which may appear simple, but there is a great deal of confusion and error about it, and we must be grateful that Prof. Fröhlich's exposition is now again available and we can see clearly expressed the relations between the various formulae such as the Kirkwood, Onsager, Clausius-Mosotti, and the conditions under which each is valid. The book also dealt with dynamical problems, and in particular the dependence of dielectric constant on frequency. This is also a very valuable chapter because the Debye equations, for example, are often wrongly used, and the conditions under which they are valid are here clearly stated.

In this second edition the main body of the book has not been changed (though the price has been increased by two-thirds), but three short additional appendixes have been added. The first two are additions to Chapter 2; the third is a brief preliminary account of the work on dielectric loss now being carried out by Sack and Gross.

A. F. Devonshire

Proceedings of the Second International Congress of Surface Activity

Edited by J. H. Schulman. Vol. 1: Gas/Liquid and Liquid/Liquid Interface. Pp. ix+521. 90*s*. Vol. 2: Solid/Gas Interface. Pp. viii+348. 75*s*. Vol. 3: Electrical Phenomena and Solid/Liquid Interface. Pp. x+621. 100*s*. Vol. 4: Solid/Liquid Interface (Washings, etc.), Cell/Water Interface. Pp. viii+352. 75*s*. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) Set of 4 volumes, £16; 50 dollars.

THIS Congress was described in *Nature* of August 3, 1957, and the Proceedings have now been published in four volumes with a slightly different arrangement from that suggested in the note on the Congress: Vol. 1 includes gas/liquid and liquid/liquid interface; Vol. 2, solid/gas interface; Vol. 3, electrical phenomena and solid/liquid interface; and the final volume deals with solid/liquid interface (washings, etc.) and cell/water interface. The washings, etc., in the title of the last volume are concerned primarily with laundering and the use of surface-active interfaces in connexion with suspensions of solids and liquids. These four volumes can be bought separately.

The classification has been on a scientific basis, but a very wide range of industrial applications is considered in addition to the main theme of detergency. Thus, froth flotation, lubrication, retardation of the evaporation of water and the many industries dependent on adsorption processes are among the topics considered.

The treatment in the papers of the Proceedings is uneven, as is obvious in the discussions that follow the individual topics treated in the different volumes. It would have been better had a more rigorous selection been made of the papers and particularly if each section could have been preceded by a reporter's summary. Nevertheless, the Proceedings give a most valuable and comprehensive interpretation of modern surface chemistry (and show how much physical chemistry can be included under this heading), with many applications in engineering fields, particularly in the realm of mass transfer.

Numerical Analysis

By Kaiser S. Kunz. Pp. xv+381. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 60*s*.

THIS book is based on notes covering lectures given by the author at the Computation Laboratory of Harvard University during 1947–49. It covers the classical field of numerical analysis—finite differences, interpolation, numerical differentiation and integration, and the solution of equations.

There is an extensive treatment of partial differential equations, and the reviewer is glad to find that the author has presented the subject in proper historical form, due recognition being given to the pioneering paper of 1918 by Liebmann. It seems, for example, that it is not generally known that the approximate solution of Laplace's equation goes back to ideas of Boltzmann and Jacobi. The Liebmann process is compared with the more recently introduced relaxation method of Southwell, and it is pointed out that the latter is far superior for hand computation but loses a good deal of its advantage when used with an electronic computer.

One short chapter is devoted to integral equations, but there is no numerical treatment, the account being confined to the theory of the numerical solution. Most chapters conclude with a set of problems, and this, together with the author's style, not too verbose and not too condensed, will make the book a useful text for students.

L. S. Goddard

Ptaki Ziem Polskich, Tom I

By Jan Sokolowski. Pp. 441+38 plates. (Warszawa: Państwowe Wydawnictwo Naukowe, 1958.) Cena zl. 80.

SOKOLOWSKI'S work on "The Birds of Poland" was first published in 1936, but the edition was well-nigh destroyed during the Second World War. This circumstance and the post-war alteration of the Polish frontiers has led the venerable author to publish a revised and re-written edition. This first volume of the work deals with the Passeres, Macrochires, Caprimulgi, Upupae, Meropes, Coraciae, Halcyones, Cuculi and Pici that are the residents, migrants and visitors of post-war Poland. The systematics and nomenclature followed are those of G. Niethammer, with a few changes according to G. P. Diemientjew. The text is well illustrated with drawings in black-and-white, coloured plates and photographs, but the low standard of production of some of the plates and most of the photographs is regrettable. The five glossaries in Polish and Latin, Russian, French, English and German are useful, but that in English contains many errors, which is surprising, as the English names in the text are given correctly.

This book is intended for both Nature-lover and ornithologist and gives accurate and penetrating records of biological observations, but there is no orderly, compact and generalized treatment of special topics such as habits, breeding and distribution. The style of writing is fluent, but so wordy and rambling that, unfortunately, it is necessary to search for much of the valuable information the book undoubtedly contains.

B. Nowosielski-Slepowron

AIR SHOWERS OF SIZE GREATER THAN 10^5 PARTICLES*

(2) ČERENKOV RADIATION ACCOMPANYING THE SHOWERS

By M. H. BRENNAN†, J. MALOS, Dr. D. D. MILLAR and C. S. WALLACE

The F.B.S. Falkiner Nuclear Research and Adolph Basser Computing Laboratories, School of Physics‡, University of Sydney

IN a series of experiments at Harwell and the Pic du Midi, Jelley and his collaborators have demonstrated the feasibility of detecting the Čerenkov pulse associated with an air shower against the background of the night sky luminosity[1–4]. Later experiments by Nesterova and Chudakov[5] have confirmed the results obtained by Jelley and Galbraith. Since the Čerenkov light is emitted throughout the atmosphere, experiments on this phenomenon are of considerable importance since they may lead to a method for investigating the longitudinal development of the air showers.

The early experiments of Jelley and Galbraith were confined to simple apparatus using a light receiver consisting of a parabolic mirror and a single photomultiplier at its focus. Small trays of Geiger counters placed at varying distances from the light receiver were used to detect the arrival of the air showers.

Jelley and Galbraith established that the pulses from the night sky, which were not identifiable as random fluctuations in the photocurrent of the photomultiplier, had an integral pulse-height distribution of the form:

$$R\,(\geqslant H) \propto H^{-1.8 \pm 0.1}$$

They further established that the rate of detecting the pulses in coincidence with a tray of Geiger counters decreased with increasing separation of the light receiver and the counter tray. It was also shown that the observed pulses had properties consistent with their being Čerenkov radiation from the electrons of the air showers. Contributions to the light from bremmstrahlung, recombination light and de-excitation light were found to be at least one hundred times smaller than the contribution from Čerenkov light[4,6].

The experiments which are described in this article were undertaken in order to investigate quantitatively the dependence of the Čerenkov light pulse on shower size and distance of the light receiver from the shower axis. Some preliminary results are also given on the angular distribution of the light. These studies are of particular importance in assessing the results of experiments, using light receivers of the type described by Jelley, to investigate anisotropy in the high-energy cosmic ray flux[3,7]. The article concludes with some comments on the applicability of air shower theory to the interpretation of the observed features of the Čerenkov light associated with air showers.

Experimental Arrangement

The light receiver is located near one end of an array of nine scintillation counters. (A complete description of the array, the method of recording pulse-heights and the method by which the size and location of the core of the shower are determined is given by Brennan, Millar and Wallace[8].) This arrangement enables us to make observations on showers of 10^5–10^7 particles the cores of which fall at distances of 0 to 60 m. from the light receiver.

The light receiver consists of seven photomultipliers with 2-in. diameter photocathodes (*E.M.I.* type 6260) clustered about the focus of a 44-in. diameter parabolic mirror. The focal length of the mirror is 18·6 in. This arrangement results in seven acceptance cones, each of half-angle approximately 3°, the axes of the outer six cones being inclined at angles of approximately 7° to the axis of the central cone, which is directed to the zenith. Tests on the optical properties of the mirror show that for angles less than 7° the circle of confusion is much less than the diameter of each of the photocathodes. For angles of about 10°, just on the outer edge of the acceptance cones, some coma in the radial direction away from the central axis is present. This does not affect the angular resolution of the instrument but may slightly decrease the gain of the outer photomultipliers for sources of small angular size.

The photomultipliers and mirror are housed in a specially constructed hut which has a plate-glass roof. A roller blind cover which is controlled by a time switch opens approximately one hour after sunset and closes one hour before sunrise. This ensures that the light-intensity incident on the photomultipliers is kept within safe limits. The time switch also controls the extra high tension to the photomultipliers.

Pulses from the photomultipliers are fed to individual pre-amplifiers mounted above the photomultipliers. A metal shield is inserted between the circuits to prevent pick-up between channels. The outputs from the pre-amplifiers are fed through coaxial line to the central recording station, where the pulse-heights in coincidence with the air showers detected by the scintillation counter array are recorded on punched paper tape[8].

Extra-high tension to the photomultipliers is supplied from a power supply which automatically adjusts the voltage so that each anode current is kept below 100 μamp. This figure is recommended by the manufacturer as an upper limit consistent with reliable operation of the tube. This procedure enables

* The first article in this series was published in *Nature* of October 4, p. 905.

† Present address: Palmer Physical Laboratory, Princeton University, Princeton, New Jersey.

‡ Also supported by the Nuclear Research Foundation within the University of Sydney.

the detector to operate despite large fluctuations in brightness which occur when low cloud passes over the detector; reflexion from city lights may then cause an increase of a factor one hundred in the light flux incident on the photomultipliers.

Results from the light receiver are used only when the extra-high tension voltage (which is approximately inversely proportional to the seventh root of the general background intensity) indicates that there is no cloud overhead. This means that, for the events which are analysed, the high tension to the photomultipliers varies from 980 V. to about 1,180 V., which is the limit set by the power supply. These variations in voltage are taken into account by normalizing all pulse-heights to their equivalent value at 1,000 V. high tension. This normalization is carried out from previously determined gain-voltage characteristics of the photomultipliers.

The gains of the photomultipliers were aligned by using the night sky as a diffuse light source and adjusting separate potentiometers supplying high tension to the photomultipliers until the anode currents were the same for all photomultipliers. The gains of the pre-amplifiers were measured *in situ*, so that the overall relative gains of the seven channels were known to about 10 per cent accuracy.

In the present work no attempt is made to make an accurate estimate of the absolute gain of the system in terms of output voltage per incident photon. However, an estimate which is probably accurate to about 30 per cent was made from the manufacturer's figures on gain and photocathode sensitivity. It was found that, for 1,000 V. across the photomultiplier, 1 V. on the coaxial line corresponds to approximately 10,000 photons incident on the photocathode. A pulse is not considered significant in the present work unless it has a normalized height greater than 0·6 V. This rather high threshold is dictated by the high background level of illumination. It is chosen so that, under the worst possible conditions, the chance coincidence rate at the minimum level is only of order 1 in 10^3 events.

Light Pulse as a Function of Shower Size and Core Location

A series of experiments was first carried out with only one of the seven photomultipliers in operation. The central photomultiplier was chosen, and events analysed only when the chart on which the high tension supplied to the photomultiplier was recorded showed that there was no cloud overhead.

A total of 206 showers was recorded for which the above condition was satisfied, and for which shower size and core location could be obtained from the response of the scintillation counter array. Of these events, 22 were accompanied by a pulse from the central Čerenkov photomultiplier of height greater than the minimum acceptable level.

No functional relationship was observed between the size of the Čerenkov pulse and the shower size, N, and the distance, R, of the core of the shower from the light receiver. Indeed, a number of events were obtained in which a large Čerenkov pulse was associated with responses in the scintillation counters too small to permit an estimate to be made of the size of shower and location of core. These pulses may be due to small showers (10^3–10^4 particles) falling very close to the Čerenkov detector or, as will be discussed later, to very large showers striking the ground far from the air shower array but passing through the acceptance cone of the receiver high in the atmosphere.

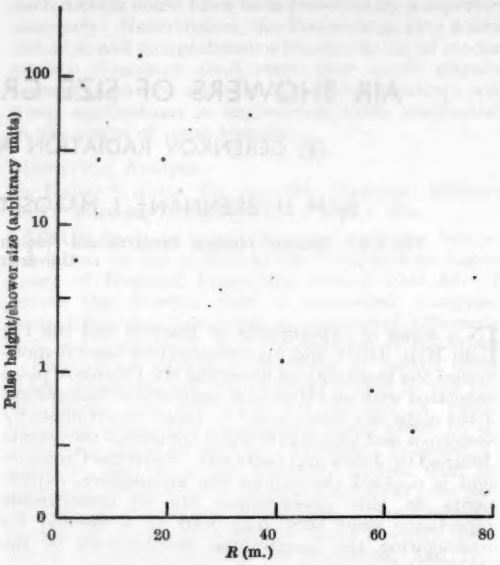


Fig. 1. Dependence of the reduced Čerenkov pulse-height on the distance, R, of the light receiver from the shower core

Fig. 1 shows the ratio, C/N, of Čerenkov pulse-height to shower size as a function of R, the distance of the core of the shower from the light receiver, for the 22 events in which a Čerenkov pulse was recorded. We note that, although there is no functional relationship between C/N and R, the maximum value of this 'reduced pulse height', as we shall call it, is a decreasing function of R.

It is of interest to investigate the fraction of showers detected by the array which were accompanied by Čerenkov pulses of different heights. An analysis of this kind is complicated by the fact that we are forced to reject pulses the heights of which are less than a fixed level (0·6 V.) independently of shower size. Thus, a pulse of, say, 1 V. from a shower of size 10^6 particles is accepted and has a reduced height of $1/10^6$, whereas a pulse of 0·5 V. from a shower of size 10^5 particles is not recorded although it has a reduced pulse-height of $5/10^6$.

In Table 1 are presented the values of the ratio of the number of showers with reduced pulse-heights greater than 10, 20, 40 and 80 (arbitrary units) to the total number of showers recorded by the scintillator array during the time of observation and in the absence of cloud. (We shall refer to such a ratio as a fractional rate.) The showers are classified according to the distance of their cores from the Čerenkov detector. The units used for the reduced pulse-heights are such that a pulse of 10 arbitrary units, associated with a shower of 10^6 particles, is equivalent to approximately 25,000 photons m.$^{-2}$ incident on the light receiver.

In compiling Table 1 we have treated the problem of a fixed minimum acceptable pulse-height by calculating upper and lower limits for the fractional rates. The lower limits are obtained by assuming that all events with normalized pulse-heights not greater than the minimum acceptable level of 0·6 V. have, in fact, zero pulse-height. Upper limits to the

Table 1. Upper and Lower Limits to the fraction of Showers accompanied by a Čerenkov Pulse as a function of the distance, R, of the Light Receiver from the Shower Core and as a function of the reduced size of the Čerenkov Pulse
The figures in brackets are the actual numbers of Čerenkov pulses recorded

R (m.)	0–20	20–40	40–60
$C/N \geqslant 10$	0·17–0·28 (9)	0·12–0·38 (12)	0·20–0·30 (1)
$\geqslant 20$	0·11–0·19 (6)	0·10–0·26 (10)	0·02–0·15 (1)
$\geqslant 40$	0·08–0·11 (4)	0·04–0·04 (4)	0·02–0·02 (1)
$\geqslant 80$	0·06–0·06 (3)	0 (0)	0 (0)
Total number of events	53	99	54

fractional rates are obtained by assuming that all such events are accompanied by a Čerenkov pulse of height equal to the minimum level of 0·6 V.

For part of the operating time during which the above-mentioned 206 showers were recorded, one of the off-centre photomultipliers was also in use. The axis of its acceptance cone was inclined at 7° to the vertical and was directed over the centre of the air-shower array. During this time 56 showers were recorded. Of these, 1 was accompanied by a Čerenkov pulse from the central photomultiplier alone, 7 were accompanied by a pulse from the off-centre photomultiplier alone, and 9 were accompanied by simultaneous pulses from both. Results from the 16 off-centre photomultiplier events are presented in Table 2 in a manner similar to those obtained from the central photomultiplier.

Table 2. Fraction of Showers accompanied by a Čerenkov Pulse from the Off-centre Photomultiplier as a function of the Distance of the Light Receiver from the Shower Core and the reduced size of the Čerenkov Pulse
The method of presentation is similar to that used in Table 1

R (m.)	0–20	20–40
$C/N \geqslant 10$	0·29–0·43 (6)	0·32–0·49 (10)
$\geqslant 20$	0·19–0·29 (4)	0·20–0·34 (7)
$\geqslant 40$	0·19 (4)	0·11 (4)
$\geqslant 80$	0·19 (4)	0·11 (4)
Total number of events	21	35

Despite the rather wide spread between the upper and lower limits to the fractional rates for both photomultipliers, it can be seen from the tables that the probability of detecting a Čerenkov pulse decreases fairly slowly with increasing distance of the light receiver from the shower core (in the range 0–60 m.) and decreases quite rapidly with increasing bias level (in terms of reduced pulse-height). We also note that the average fractional rate for the off-centre photomultiplier (16/56 = 29 per cent) is greater than that for the central photomultiplier (22/206 = 11 per cent). Also, the fractional rate does not decrease as rapidly with increasing bias-level in the case of the off-centre photomultiplier. We shall see later that this may be understood qualitatively in terms of the integrated particle flux in the respective acceptance cones.

Again, for part of the operating time three collinear photomultipliers were in use, resulting in three acceptance cones with coplanar axes, one inclined at 0° and two at 7° to the vertical. Three events were recorded in which all three photomultipliers gave simultaneous pulses.

Angular Spread of the Čerenkov Light

The results presented in the preceding section indicate that the height of the Čerenkov pulse does not bear a simple relation to the shower size, N, and the distance, R, of the light receiver from the shower core. A possible explanation for the occurrence of large fluctuations in the pulse-heights lies in the fact that the air-shower electrons do not all travel in a direction parallel to the shower axis; the Coulomb scattering of the electrons can lead to the emission of Čerenkov radiation from the shower at an angle to the shower axis considerably greater than the angle of emission from a single particle (1·3° at sea-level).

That light is indeed emitted with a large angular spread from individual air showers is indicated by the results presented in the previous section, where it was noted that coincident pulses from two, and even three, photomultipliers looking in different directions were not uncommon. In the case of the three-fold coincidences, the angular spread of the light must be at least 7°.

Further information on the angular distribution of the light was obtained from an analysis of 157 showers for which, in addition to an estimate of the shower size and core location, the direction of incidence of the shower axis was known. This latter information was obtained by a timing technique which has been described briefly elsewhere[9]. As in the investigations on the radial dependence of the Čerenkov light, only the central vertical-looking photomultiplier was used. We may therefore identify the angle of emission of the light (with respect to the shower axis) with the zenith angle of the shower axis (see Fig. 2).

Of the 157 showers analysed, 20 were accompanied by a Čerenkov pulse from the central photomultiplier. The events were first classified into two groups:

Group 1. Showers for which the minimum distance between the axis of the acceptance cone and the axis of the shower occurred above ground; that is, showers which passed 'over' the detector before striking the ground. There were 74 such showers, of which 13 were accompanied by a Čerenkov pulse.

Group 2. Showers for which this minimum distance occurred below ground; that is, showers which struck the ground before reaching the detector. There were 78 of these, of which 7 were accompanied by a Čerenkov pulse.

Within the limits of these statistics, then, a shower crossing over the light receiver is twice as likely to give a Čerenkov pulse greater than our detection limit as is a shower which does not do so. This result would lead one to the view that the size of the light pulse detected is likely to be strongly dependent upon the number of particles traversing the acceptance cone of the mirror.

In order to obtain more detailed information on the angular distribution of the Čerenkov light, we next considered only those events where the skew distance between the shower axis and the axis of the acceptance cone was less than 20 m. Of the 87 showers which satisfied this additional requirement, 10 were accompanied by a Čerenkov pulse. Results for these events are presented in Table 3, in which the fraction of showers accompanied by a Čerenkov pulse is given for several ranges of zenith angle. The method of presenting the results is similar to that used in compiling Tables 1 and 2.

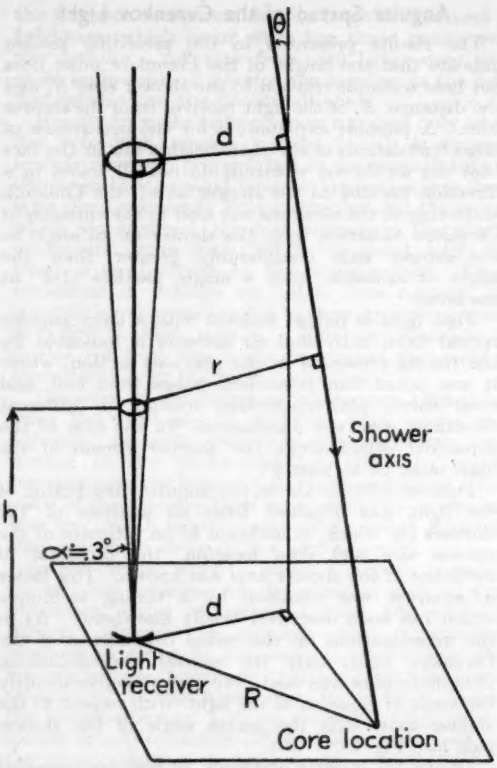


Fig. 2. Schematic diagram of a shower passing 'over' the light receiver

The most significant feature of these results is that the Čerenkov light may be emitted at angles of at least 30° to the shower axis. We thus see that it is not correct to assume that the Čerenkov light is emitted only by particles travelling parallel to the shower axis. As we shall show in the next section, this result is entirely consistent with the theoretically predicted angular distribution of the electrons in a shower. It is also in accord with the numerous photographs of shower electrons in cloud chambers which have been obtained in this laboratory and elsewhere.

The efficacy of the light receiver as a detector possessing a high angular resolution for studies of the anisotropy of air-shower primaries was also investigated, with results shown in Fig. 3. Here are plotted the zenith angle distributions of the 20 showers accompanied by a Čerenkov pulse from the vertical-looking photomultiplier together with the corresponding distribution of all the 157 analysable showers among which the 20 events occurred. It will be seen that for these showers, the cores of which have fallen within a distance of 60 m. from the detector, the requirement that a Čerenkov pulse be recorded has introduced a bias toward vertically incident showers. Half the showers detected by the scintillator array have zenith angles greater than 20°–25°; the corresponding half-angle for the Čerenkov events is 10°. This gain in angular resolution, however, is offset by the accompanying reduction in rate of events recorded.

It should also be emphasized that this result refers to detected showers the cores of which fall close to the detector. The angular distribution of showers detected using a light receiver alone could be quite different, as discussed further below.

Table 3. Upper and Lower Limits to the Fraction of Showers accompanied by a Čerenkov Pulse as a function of θ, the Angle of Emission relative to the Shower Axis, and C/N, the reduced size of the Pulse

The method of presentation is similar to that used in Table 1

Zenith angle (deg.)	0–10	10–20	20–30	⩾ 30
$C/N \geqslant 10$	0·50–0·67 (6)	0·11–0·42 (2)	0·03–0·23 (1)	0·06–0·19 (1)
⩾ 20	0·50 (6)	0·05–0·16 (1)	0·03–0·17 (1)	0·06–0·19 (1)
⩾ 40	0·17 (2)	0·05 (1)	0·03 (1)	0 (0)
⩾ 80	0·08 (1)	0·05 (1)	0·03 (1)	0 (0)
Total number of events	12	19	30	16

Discussion

The foregoing results indicate quite clearly that the light emitted by the cosmic-ray air shower traversing the atmosphere may be detected at large angles from the shower axis. This fact is not inconsistent with the interpretation that the light is Čerenkov radiation when one considers the angular distribution of the air-shower electrons arising from their Coulomb scattering in the air. Indeed, according to the calculations of Richards and Nordheim[10], the electron angular distribution is expected to be quite broad and for electrons of energy greater than 21 MeV. (the threshold energy for Čerenkov emission in air at normal pressure) the root mean square angle of the electrons relative to the shower axis is 10°.

Although it is not the purpose of the present article to discuss in detail the theoretical interpretation of the Čerenkov light associated with an air shower, it does appear worth while to indicate an approach which should prove useful. For the sake of simplicity we shall ignore the longitudinal develop-

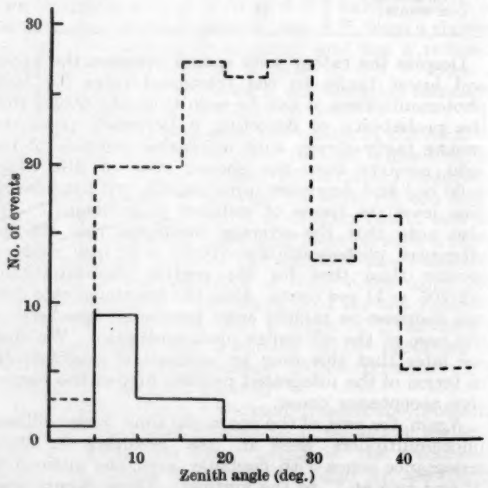


Fig. 3. Zenith angle distributions of 157 showers detected by the scintillator array (dotted line) and of the 20 showers accompanied by a pulse in the vertical-looking light receiver (full line)

ment of the shower. This could be introduced at a later stage when more experimental results are available.

Let us consider the case of a shower of size N, the axis of which is inclined at an angle θ to the axis of the acceptance cone of the receiver. Our notation is as shown in Fig. 2. We first define an average particle density at a particular height h, $\overline{\rho}(h)$. We then define a function $f(\theta,r)d\omega$ which is the fraction of electrons at a distance r from the shower axis which have energies greater than 21 MeV., the threshold for Čerenkov emission at sea-level, and which are travelling at an angle θ to the shower axis in the solid angle $d\omega$.

This angular distribution of the electrons gives rise to an angular distribution, $f'(\theta,r)d\omega$, of the photons. Since the angle of Čerenkov emission (1·3° at sea-level) is much less than the root mean square angle of the electron distribution we may, to a good approximation, replace $f'(\theta,r)$ by $f(\theta,r)$. We may further simplify the problem by replacing $f(\theta,r)$ by $f(\theta,d)$, where d is the skew distance between the shower axis and the axis of the acceptance cone. This appears to be justified since, for the low electron energies considered here, $f(\theta,r)$ will be a slowly varying function of r.

With the above assumptions, the contribution of the electrons at a height h to the number of photons detected by the light receiver is:

$$n(h)dh = k dh\, \overline{\rho}(h)\, f(\theta,d)\, \pi h^2\alpha^2 d\omega = k\overline{\rho}(h)\, f(\theta,d)\, \pi A\alpha^2 dh \text{ photons},$$

where k is the number of photons emitted per particle per unit track length, $d\omega = Ah^{-2}$ is the solid angle presented to the light flux by the mirror of area A and α is the half-angle of the acceptance cone.

If we ignore the variation of k with h, the total number of photons detected will be given by:

$$N = C\int_0^\infty \overline{\rho}(h)\, dh$$

where $C = k\, f(\theta,d)\, A\pi\alpha^2$. That is, the number of photons detected is determined by the integrated particle-density above the detector, and is also determined by the angular distribution of the electrons in the shower.

The experimental results reported in this article are in qualitative agreement with this model. The large fluctuations in the values of C/N as a function of r in Fig. 1 may be ascribed to the fact that the showers detected are not in general vertically incident. The off-centre photomultiplier, which looks out over the scintillator array, detects light pulses in coincidence with air showers detected by the array with greater frequency than does the vertical-looking photomultiplier. The average pulse-height is also greater. Since the majority of showers detected fall with their cores inside the area containing the scintillator array, there is a larger number of shower cores traversing the acceptance cone of the off-centre photomultiplier than is the case for the vertical-looking one.

The distribution of zenith angles of showers the axes of which fall within a skew distance of 20 m. from the axis of the vertical-looking detector is given in Table 3. Knowing the shower structure function, the position where the core has hit the ground and the direction of the shower axis, it is possible to carry out the integration, $\int_0^\infty \overline{\rho}(h)dh$, along the axis of the detector. This has been done approximately for the events of Table 3, and the angular distribution function $f(\theta)$ for the photons, ignoring its possible dependence upon d, has been found to be consistent with the form $f(\theta) \propto \theta^{-0.7}$.

Finally, it is clear from the results shown in Fig. 3 that a vertical-looking light receiver in conjunction with an array detecting air-shower particles will respond to showers falling within a narrower range of zenith angles than would be the case for the detecting array alone. This selection of vertical showers may be produced not only by the forward peaking of the angular distribution of photons about the direction of the shower axis, but also by the larger value of the integrated particle density for a vertical shower.

As pointed out earlier, this selection of near-vertical showers has been shown to apply only to showers the cores of which fall close to the detector. It is quite probable that an air-shower detector consisting of a light receiver alone will respond to showers of quite wide zenith angle distribution, many of the showers detected by it, in fact, traversing the acceptance cone of the receiver at large angles and falling far away from the detector.

Conclusion

From the results reported in this article, it is apparent that in the interpretation of the light pulses associated with the extensive air showers, it is not justifiable to ignore the angular distribution of the air shower particles and the consequent angular distribution of the emitted photons. As a device for the investigation of possible anisotropies in the directions of arrival of the air shower primaries, the Čerenkov detector pointed to the zenith in conjunction with a particle-detecting array will accept showers within an acceptance cone of half-angle appreciably wider than the half-angle of the detector itself. Further investigation is required before one can hope to use the Čerenkov emission from air showers as a means of investigating their longitudinal development.

We wish to acknowledge the facilities made available for this work by Prof. H. Messel and the invaluable support given by the Nuclear Research Foundation. One of us (M. H. B.) has been supported in this work by a grant from General Motors–Holden's, Ltd., and another (C. S. W.) by a grant from the Australian Atomic Energy Commission.

[1] Jelley, J. V., and Galbraith, W., *Phil. Mag.*, **44**, 619 (1953).
[2] Galbraith, W., and Jelley, J. V., *Nature*, **171**, 349 (1953).
[3] Jelley, J. V., and Galbraith, W., *J. Atmos. Terr. Phys.*, **6**, 304 (1955).
[4] Galbraith, W., and Jelley, J. V., *J. Atmos. Terr. Phys.*, **6**, 250 (1955).
[5] Nesterova, N. M., and Chudakov, A. E., *Zhur. Eksp. Terr. Fiz.*, **28**, 384 (1955).
[6] Barclay, F. R., and Jelley, J. V., *Nuovo Cim.*, **2**, 27 (1955).
[7] Watt, J. S., M.Sc. thesis, University of Sydney (1956).
[8] Brennan, M. H., Millar, D. D., and Wallace, C. S., *Nature*, **182**, 905 (1958).
[9] Brennan, M. H., Lehane, J., Malos, J., Millar, D. D., Wallace, C. S., and Winn, M. M., Proceedings of the IUPAP Cosmic Ray Conference, Varenna (1957). To be published in a supplement to *Nuovo Cim.*
[10] Richards, J. A., and Nordheim, L. W., *Phys. Rev.*, **14**, 1106 (1948).

RADIO AIDS TO NAVIGATION

At a meeting on September 2 of Section G (Engineering) of the British Association in Glasgow, three papers were read on the subject of "Radio Aids to Navigation". The first of these, by Dr. R. L. Smith-Rose, outlined the general problem and dealt with the principles of the determination of position by the use of radio waves. The other two papers, by Dr. B. G. Pressey and Mr. Caradoc Williams, respectively, described the present state of development of radio aids for marine and aeronautical navigation.

From the earliest days of radio the position of a transmitting station has been determined by the technique of radio direction finding. Using a special aerial system, which may be fixed or rotatable, for receiving waves from a transmitter its direction or bearing may be ascertained. With two or more such direction finders the position of the transmitter is determined by the intersection of the bearing lines. In the first half of the twentieth century various direction-finding systems were developed for use on land, ships and aircraft; and, as a result of much scientific research, the accuracy and scope of such systems have been steadily improved. The application of the technique has been very wide and includes not only navigation but also the location of unidentified transmitters and the sources of thunderstorms. A recent extension has involved the tracking of artificial satellites by the signals emitted by it.

An alternative technique places the directional aerial system at the transmitter, and by suitable coding signals, the bearing of this station can be determined from any receiving point. There are several varieties of such directional beacon transmitters, which are in many ways analogous to the ordinary lighthouse from a navigational point of view. In one type the transmitted signal is directed along a particular route, and switched periodically to either side of this direction. By maintaining a position giving equal received signal strengths, a craft can be navigated along the prescribed course. The Consol system provides a variation on this in that a number of courses are specified by an appropriate coding of the transmitted signals, which change systematically over a period of operation, usually half a minute. An observer using an ordinary receiver, and knowing the approximate direction of the transmitter, can make a precise determination of this direction by merely observing the code signals during the operating period.

The development of radar has resulted in the use of an additional technique involving a measurement of the time of transit of the radio waves between sender and receiver, and so of the distance between these stations. The combination of distance and bearing makes it possible to determine position from a single point without the need for cross-bearings as in normal direction finding.

Among the more recent developments are those which are classified under the title of hyperbolic systems. If synchronized pulses are emitted from two stations they will, in general, be received at different times at a remote station on land, at sea or in the air. Using a cathode-ray tube type of presentation, the received pulses can be displayed on a suitable time base, and their relative times of arrival measured with considerable accuracy. The locus of receiving points at which there is a constant time difference is a hyperbola. Thus the observation of the time difference between the pulses locates the receiver on one of a system of hyperbolæ. If a third transmitting station is included in the chain, a second observation defines the position on one of another system of hyperbolæ, and the point of intersection gives the position of the observer. This is the basic principle of the Gee and Loran systems of navigational aid. Similar networks of hyperbolic loci can be established with continuous wave transmitting stations, as in the Decca system. In this case the hyperbolæ are distinguished by a constant phase difference between the signals received from pairs of stations.

Marine Navigation

From the mariner's point of view, the two principal navigational questions to which he requires an answer are, "Where am I?" and "How far am I from danger?" In conditions of poor visibility these questions can only be answered satisfactorily by radio.

Mention has already been made of the oldest type of radio aid, the direction finder, the main use of which is as a ship-borne instrument operating in conjunction with a world-wide beacon network. Developments during the Second World War have given the mariner three new aids: the long-range directional beacon, hyperbolic position-fixing systems and radar. The first, known as Consol, enables a ship to obtain a bearing with the aid of a normal radio receiver by merely listening to the coded signal. The accuracy of the position obtained in this way depends on the distance of the observer from the beacon; up to a range of 1,000 miles from the beacon, it varies from a few miles to about 20 miles. The principle of operation of the hyperbolic position-fixing system is based on the determination of the difference in the distances of the ship from two fixed points by the measurement of the difference in the times of travel of radio waves transmitted from those points to the ship. Two systems of this type are the Decca Navigator, using continuous waves for medium range operation, and Loran, using pulse transmissions for longer range use. Special measuring equipment is necessary at the receiving end in each case, but this has now been developed to the stage of giving the navigator a direct reading of the co-ordinates of his position. Chains of Decca transmitting stations now cover the whole of the British Isles and a large part of Western European waters; there are also four chains in operation in Eastern Canada. The position-fixing accuracy of the system varies from a few tens of yards in favourable areas to a few miles at night at the nominal 240 nautical mile limit of range from the master station. Loran is essentially a long-range system using pulse-modulated signals radiated from pairs of stations spaced 300–600 miles apart. The service range extends to about 700 miles over sea in the daytime, and because of better propagation conditions, to about 1,500 miles at night. The position-fixing accuracy is high, being about 0·5 per cent of the range, that is, 5 nautical miles at 1,000 miles.

Ship-borne radar enables the mariner to 'see' land and certain types of landmarks up to distances of twenty miles or more and, by measuring the distances to identifiable points, he can easily plot his position

on a chart. The more important use of radar, however, is to indicate the presence of other shipping and navigational marks, and so give warning of danger and enable narrow channels to be navigated in thick weather. Shore-based radars are now being used for harbour approach surveillance, information on a ship's position being passed to the pilot by radio telephony or, probably in the near future, by televizing the radar screen. Further developments now under consideration include position fixing systems of very wide coverage and devices to increase the amount of information given by the radar.

Special Problems of Aircraft Navigation

Aeronautical navigation involves the planning and control of the movement of aircraft in position and time along defined tracks so as to reach a prescribed destination in safety. The increasing density of air traffic, particularly in the vicinity of the international airports, creates the need for aircraft to operate in closer proximity and with greater regularity during adverse weather conditions. Radio navigation aids now play a vital part in the safe movement of aircraft; and improved accuracy, greater range of operation, up-to-date information and simplified presentation are the primary requirements. Special problems are present in aeronautical navigation because aircraft move at high speed in three dimensions in a medium of low density. The requirements of aeronautical navigation can be conveniently grouped into three classes: (1) long-range navigation beyond about 250 miles when radio signals propagated by reflexion from the ionosphere may be used; (2) short-range navigation up to about 250 miles when surface wave propagated signals may be used in the metric or centimetric wavebands; (3) very short-range precision navigation such as is required for the guidance of aircraft on to an airfield runway, when metric or centimetric wave-length signals may be used.

The methods of navigation may employ the integration of movement with respect to time relative to a fixed point or the movement may be measured within a fixed co-ordinate framework such as a bearing-distance lattice or a hyperbolic lattice. Dead reckoning is an example of the former process, but the errors in the measurement of airspeed and drift angle have necessitated the development of the Doppler system of radio navigation, which measures accurately the ground speed and drift angle, thus enabling an accurate computation of movement to be provided without the support of radio services from the ground. The facility is of great value for navigation over oceans or in undeveloped parts of the world. Since the process involves the integration of movement with time to ascertain a new position, the accuracy of the result is directly related to the quality of the information used and the integration time. The error in the position of one aircraft is unrelated to the error in position of another aircraft which may be in proximity to it, and under these conditions the measures necessary to prevent collision are obscure. The ideal system of navigation will provide increasing accuracy as the points of danger are approached.

These limitations of the processes employing time integration are the primary reason for the use of systems which lay down a fixed co-ordinate framework in which the aircraft move. If this co-ordinate framework is in use by all aircraft within its coverage, the relative errors in the positions of aircraft are highly correlated and the degree of correlation increases as the craft approach one another.

The simplest form of aeronautical navigation is by use of an airborne direction finder called the automatic radio compass, which provides fixing or homing information with respect to simple low-power non-directional ground beacons or to broadcast stations. By present needs, the aircraft radio compass is a rather inaccurate device because of the small physical size of the loop aerial, and the difficult siting conditions for the loop on the aircraft fuselage. Furthermore, substantial errors can occur at night resulting from signals reflected by the ionosphere which are not plane polarized.

For long-range navigation, low-frequency continuous wave or pulse modulated signals may be used. These are radiated from widely separated stations which are time interlocked to define a hyperbolic co-ordinate system. Groups of three or more stations form a chain, from which a position can be derived from two or more intersecting hyperbolic position lines. An example of this system is Dectra, which uses continuous wave signals in the 70 kc./s. band to provide track and position along a number of airways which may be 2,000 miles or more in length. It makes use of both ground and ionospheric wave reflected signals depending upon the distance from the stations. The Loran system already referred to has also been widely used for aeronautical purposes.

For short-range navigation, both distance-bearing systems and hyperbolic systems are used. The V.O.R. system provides the means of flying along any radial track by receiving modulated very high frequency signals from a ground beacon which shows the direction of the beacon on a bearing type indicator. A pulse-modulated distance-measuring equipment called D.M.E. can be used in conjunction with it, in which pulse interrogations originating from an aircraft trigger a ground beacon which gives pulse replies, the round trip time being used to indicate distance on the scale of a meter. The problems of the equipment accommodation and the location of the separate aerials in an aircraft necessitated an effort to integrate the bearing and distance services together. This has been achieved in a pulse-modulated system called TACAN, which operates in the 1,000 Mc./s band. As in D.M.E. the pulse signals are initiated in the aircraft and replies are given from a ground beacon which indicates to the pilot the distance of the aircraft from the beacon. The ground-to-air transmissions from the beacon are space modulated to carry bearing information, which is presented on a circular scale bearing indicator, the distance from the beacon being visible in a small window in the indicator dial.

An alternative short-range hyperbolic navigation is provided by the Decca Navigator. By the use of low frequencies of the order of 100 kc./s. and spacing the master and slave stations by 50–100 miles apart, a hyperbolic system of high accuracy is provided. For use in aircraft where instantaneous position indication is required a display is used which shows automatically the movements of the aircraft upon a map.

Some kinds of navigation require great precision over a limited area of coverage, as, for example, the landing of aircraft during bad visibility. These movements create hazards where the points of danger are imminent, and the navigation aids must provide immediate and accurate information. At present, guidance can be given in azimuth and descent by using a precision radar located on the airfield. A ground controller gives a verbal commentary of the approach situation to the pilot on the very high frequency communication channel. He gives the pilot courses

to steer, rate of descent and other information during the approach to the airfield until the pilot is within visual distance of the runway.

An alternative form of airfield guidance is by the instrument landing system (I.L.S.), which sets up radio beams to define the lateral and descent path of the aircraft to the airfield runway. The aircraft displacement from the defined track is indicated to the pilot on a meter which has two needles pivoted at right angles. The intersection of the needles with respect to the centre of the dial indicates the correction which the pilot has to make to restore his position on the beam. With large aircraft the practice is being introduced to link these guidance signals to the automatic pilot, so that the descent to the airfield is made under automatic flight control, with the pilot acting as a supervisory monitor to the approach. When he sees the airfield landing lights he takes over full manual control of the aircraft until it is at rest on the runway. The need for complete reliability of the control equipment at this crucial stage is a matter of paramount importance.

MODERN PROBLEMS IN FRICTION AND LUBRICATION

A JOINT meeting of Sections A (Physics) and G (Engineering), under the chairmanship of Prof. J. Small, was held on September 2 at the British Association meeting in Glasgow. In opening the session Dr. F. P. Bowden (University of Cambridge) discussed some problems involved in travelling at speeds of the order of 2,000 m.p.h. The first part of his paper described work in collaboration with Dr. E. Freitag on sliding friction between solid surfaces at these enormous speeds. Elegant experiments using apparatus based on Prof. Beams's magnetic ultracentrifuge had made it possible to study this in the laboratory. At slow speeds of sliding the friction between clean metals is very high, and heavy seizure and surface damage occur. As the speed is increased, however, the friction falls and at sliding speeds of 2,000 m.p.h. it is very low indeed—of the same order as for lubricated surfaces. It would seem that at these speeds the frictional heating which is generated at the sliding interface is sufficient to melt a thin surface layer of the metal; this acts as a lubricant and enables the surfaces to slide easily with low friction and little damage. As a result it may be easier to slide metals over one another at 2,000 m.p.h. than at normal speeds.

Unfortunately not all metals behave in this way. With antimony, for example, surface melting and low friction occur at speeds below 800 m.p.h., but at speeds exceeding this the metal becomes brittle and disintegrates into a fine dust.

The second part of Dr. Bowden's paper described work done in collaboration with Mr. J. H. Brunton on the way in which solids may be damaged if they are hit by rain-drops travelling at speeds of 2,000 m.p.h. A demonstration was given of shooting small cylinders of water (corresponding in volume to a rather large rain-drop) at various surfaces at speeds of this order, the main part of the apparatus being a simple airgun modified to produce the required result. With even the hardest metals the pressures developed at the region of impact are sufficient to produce plastic flow and a saucer-shaped crater is formed in it. With plastics, glasses and ceramics which are strong in compression but weak in tension the behaviour is, however, quite different. The region at the edge of the impact area is subjected to large tensile forces and circular ring cracks are formed. These cracks penetrate beneath the surface and a few successive impacts can cause a large piece of the material to fall out.

Another source of damage which can be even more serious arises from the reflexion of the shock-wave (generated by the impact) in the solid. This travels back as a tensile stress and can detach large fragments of solid from the rear face of the solid. In conclusion Dr. Bowden emphasized that "if we wish to go hurtling around the Earth at a few thousand miles per hour we must learn more about the way in which solids slide, bend and break at very high speeds".

The second contribution, on "Rolling, Skidding and Sliding", was given by Dr. D. Tabor (University of Cambridge). He pointed out that in ordinary sliding the friction was due to two main factors: the shearing of interfacial junctions and the grooving or deformation of the softer surface by asperites on the harder. For most sliding systems the second factor was of minor importance, but there were two situations where it tended to dominate the frictional behaviour. The first was in pure rolling. Even if junctions were formed, the work required to peel the surfaces apart was immensely smaller than the force required to shear these junctions in sliding. The main factor now remaining was the work of deformation, and this could be appreciable even if the surfaces are deformed only elastically. The loss of energy is due to elastic hysteresis in the solids and a demonstration was provided showing that the rolling friction on a rubber of low hysteresis loss was considerably less than on a rubber of high hysteresis loss.

The second situation is observed in pure sliding if the surfaces are so well lubricated that the shearing of the interfacial lubricant film requires only a very small force. In such a case the deformation of the underlying surface may again dominate the frictional behaviour. Thus for hard sliders rubbing on well-lubricated rubber the friction is determined primarily by deformation losses in the rubber itself. A demonstration showed that when rubber slides over a rough, well-lubricated surface the sliding friction is greatly increased if a rubber of low resilience or high hysteresis loss is used. Dr. Tabor concluded by suggesting that a combination of tyre-treads of non-resilient rubber and roadways with a 'knobbly' surface could appreciably reduce the risk of skidding on wet or slippery roadways.

The third paper, on "Lubrication in the Nuclear Age", was given by Dr. C. G. Williams (Shell Research, Ltd.) and dealt with those special mechanisms in nuclear power stations which require lubrication and are exposed to heavy irradiation. Most lubricants deteriorate as a result of irradiation, the deterioration being determined by the energy of the irradiation and not by its type (neutrons, electrons, gamma-rays).

Irradiation energy leads to a break-up of the lubricant molecule with subsequent polymerization and the formation of gumlike or even solid products. Non-petroleum synthetic materials such as silicones do not appear to be very resistant to irradiation; ordinary hydrocarbon oils are somewhat better but the compounds most capable of resisting the harmful effects of irradiation are aromatic hydrocarbons. Apparently the aromatic molecule can absorb energy and then emit it as heat or light without decomposing.

Conventional greases are particularly susceptible to irradiation. They generally consist of a network of soap fibres which encloses the oil globules. Irradiation appears to fragment the fibres so that separation of the oil takes place. A new type of grease has now been evolved in which the soap fibres are replaced by minute clay particles. These particles are strongly attracted to one another and are unaffected by radiation. The grease structure is thus stable, and by using an oil containing a large fraction of aromatic materials a grease is obtained which stands up to irradiation surprisingly well. Dr. Williams's lecture concluded with a short film which illustrated the main themes of his paper.

The fourth paper, by Dr. F. T. Barwell (Mechanical Engineering Research Laboratory (D.S.I.R.), Thorntonhall), dealt with "Newer Aspects of Hydrodynamic Lubrication". He provided a simple direct demonstration of Beauchamp Tower's famous experiment of 1885 which showed that the lubricant between a journal and a bearing developed high hydrostatic pressures capable of supporting the load on the journal. It was this work which led to Osborne Reynolds' classical theory of hydrodynamic lubrication. Although Reynolds' work was of immense importance and had been greatly extended by the use of modern electronic computers there were at least four deficiencies which recent work has revealed. First, Reynolds assumed that the oil film cannot support negative pressures whereas experiments now show that negative pressures in the oil film can exist. Secondly, the oil film is not continuous but breaks up into fibrils in the regions of negative pressure. Thirdly, Reynolds assumed that the viscosity was constant whereas modern work shows that viscous heating reduces the viscosity, while high pressures increase it. Finally, because of thermal effects and elastic flexing of the shaft, bearings run more satisfactorily at high speeds if they are narrower than the classical theory suggests.

Two other problems of current importance arise if the load is not constant in a uniform direction. If the load rotates it can be shown that a critical condition exists when the frequency of the applied load is half that of the shaft. The load-bearing capacity of the bearing becomes vanishingly small and there is very great danger of bearing-failure. The second type of instability which has attracted considerable attention in recent years is that associated with shaft vibration or whirl, and several procedures have been developed for minimizing its more serious features.

Finally, Dr. Barwell referred to the possibility of using air as a hydrodynamic lubricant and demonstrated a commercial electric motor which, with only slight modifications, operated very successfully on air bearings.

The last paper, by Dr. J. F. Archard and W. Hirst (Associated Electrical Industries, Aldermaston), on "The Wear of Metals", was presented by Dr. Archard. The results of many hundreds of wear experiments have led to four relatively simple rules of wear. The first general rule is that at the start of a wear experiment the rate of wear changes as the surface conditions change, but eventually these become stabilized and steady wear conditions obtain. Secondly, under steady conditions the wear rate becomes constant and is roughly independent of the area of the rubbing surfaces. Thirdly, for many materials the steady-state rate of wear is almost proportional to the load. Finally, with metal surfaces there are two main types of wear, 'mild wear' below a critical load and 'severe wear' above it. Under conditions of mild wear, the worn fragments are usually very small, perhaps only a few hundred angstroms across, whereas in severe wear large lumps of metal are torn out of the surfaces.

Although in certain cases a wear fragment may be produced when an asperity on one body shears through the surface layers of the other this is not generally the case. Elegant experiments using radioactive transfer techniques show that in many cases one metal transfers itself as a thin film on to the other as a result of adhesion and shearing of interfacial junctions. The transferred fragments then gradually coalesce and are fatigued by repeated rubbing until they break away from the surface and appear as wear fragments. The exposed surface then becomes covered with a new layer of transferred material and the process continues in this way. The results show that the wear process is often very complex indeed. Finally, Dr. Archard discussed the mechanism of wear in terms of a model involving asperity encounters in which all the encounters contributed to the friction but only a small fraction of the encounters could lead to wear. This model was consistent with the enormous range of wear-rates observed for different materials. Thus although the coefficient of friction for the most diverse solids does not vary by more than a factor of three or four the wear-rates may vary by a factor of more than 100,000. D. TABOR

THE INSTITUTE OF METALS

ALTHOUGH there has been a non-ferrous metallurgical industry in Britain from time immemorial, it was not until 1908 that any organization was available for the general dissemination of knowledge and research in this field. The Iron and Steel Institute had performed such a function for its own branch of metallurgy since 1869, and mining and the extraction of metals, chiefly non-ferrous, were covered by the publications of the Institution of Mining and Metallurgy.

It may well be that the delay in the formation of a body such as the Institute of Metals, which celebrates its golden jubilee this year, was in large measure due to the secrecy which obtained. From the earliest days existing knowledge had been passed on from master to apprentice, and at a later age the guilds had, as part of their functions, to ensure that the apprentice received an adequate training and gave satisfactory proofs of proficiency in his trade before passing on to higher status. It was inevitable

in such circumstances that existing knowledge should be restricted to those in the immediate circle, and a similar secrecy existed, though to a diminishing degree, even down to very recent times. Even after the formation of the Institute, successive presidents, year after year, had in the earlier stages of its life to plead for more papers of a 'practical' nature.

It did, therefore, represent a much more liberal outlook when a preliminary meeting, mainly of those concerned in the copper and brass industries, met in Manchester in 1908 to consider the formation of an Institute much on the lines of the existing ones, but for the non-ferrous metals. At a subsequent meeting in London it was resolved that such an Institute, to be called the Institute of Metals, be formed, and the new body held its first meeting in Birmingham in that year.

This Institute has performed many useful functions, but it may be that none of these will ultimately prove to have been of greater industrial value than its general dissemination of experience and new knowledge, not only in Britain but also throughout the world. In its fifty years of life there has been a quite revolutionary change in this respect, and such interchange of information, even between competing organizations, is now the rule rather than the exception. Perhaps there is no more concrete evidence of this fact than the success with which the Institute, largely through its Metallurgical Engineering Committee, has been able to organize symposia, such as those on "Internal Stresses in Metals and Alloys" or "The Metallurgical Aspects of the Hot (and later Cold) Working of Non-Ferrous Metals and Alloys". In those symposia an enormous amount of practical, factual material of the highest importance to industry was published and very frankly discussed.

So far it is the directly practical aspect of the Institute's activities and influence which has been considered, but there is another, and no less important, side to its work. Until its formation, publication of scientific research on the non-ferrous metals was dispersed throughout a wide field of publications. Now, for the first time, a single focus was available in which the vast majority of work done in Britain, and to some extent abroad, was collected. From its very inception the standard of the papers which the Institute has published has been high, and never more so than to-day, and its *Journal* is rightly regarded throughout the world as a scientific publication second to none in the metallurgical field. How much, for example, the development of age-hardening alloys owes to the papers which the Institute of Metals has published cannot, of course, be adequately assessed, but there is no doubt that in this, and in many similar fields, the work which it has published has played an outstanding part.

At one time it was directly concerned with the experimental investigation of corrosion, particularly of condenser tubes, and the success with which this was carried out may be gauged from a testimony of Sir Winston Churchill who, in introducing the Navy estimates for 1940, said: " 'Under the adverse circumstances', to quote a hero's phrase, our ships great and small have been at sea more continually than was ever done or dreamed of in any previous war since the introduction of steam. Their steaming capacity and the trustworthiness of their machinery is marvellous to me, because the last time I was here one always expected a regular stream of lame ducks from the fleets to the dockyards with what was called 'condenseritis', or heated bearings, or other mechanical defects. But now they seem to steam on for ever".

It was realized, however, that the active pursuit of research was not the true function of such an institute, but its single excursion into such a field was highly successful.

To one who, like the present writer, entered metallurgy before the era of the modern—and perhaps he may be allowed to say hypothetical—aspects of metallurgical research were even thought of, it is not easy to assess their ultimate importance in connexion with metallurgical science and technology. When, however, the vast amount of published work which has been coming out from research institutions of all kinds in an ever-increasing flood has been brought together in more concrete terms, a new attitude may well initiate a completely new point of view to producers and users alike, and if this should prove to be the case, those workers whose results have appeared in the Institute's *Journal* and, be it said, all those responsible for the production of this most excellent publication will have played a yeoman part.

It would be quite improper in such a consideration of the Institute's activities to omit mention of the excellent abstracts, which have formed an essential part of its publications from the first. These, in their scope and presentation, are recognized as being inferior to none in the metallurgical or, probably, in any other field.

Another activity of the Institute is represented by its 'May' and 'Autumn' Lectures. The former (generally delivered in March) is a scientific oration not of direct industrial significance but at the same time not without its indirect bearing. The Institute has been particularly fortunate in the men of highest reputation who have accepted its invitation to deliver these lectures. Sir William and Sir Lawrence Bragg, Sir J. J. Thomson, Lord Rutherford, Sir Henry Miers, Sir Willis Jackson are names which come immediately to mind. Through these lectures the members are introduced to fields of knowledge which, though not immediately applicable, may at any time become so. The Autumn Lecture, on the other hand, is concerned with some matter of a more practical nature, often of special importance to the district in which the meeting is held.

In this, as in the case of any similar institute, its growth and influence are directly due to the efforts of those men who work for, and direct the progress of, the organization. A mere list of names of such men would, in the case of the Institute of Metals, be quite formidable, and it is no easy task to pick out even a few whose influence has been of outstanding value. Two of these, however, must clearly be Mr. G. Shaw-Scott, the first full-time secretary of the Institute, who acted in that capacity until his retirement in 1944, and his successor, the present secretary, Lt.-Col. S. C. Guillan. It has been the policy of the Institute from the beginning to choose its president and council in more or less equal numbers from the producer, the user and the scientist, and in all these groups men of the highest attainments have served. The first president of the Institute, Sir William White, had been the director of naval construction and, as consultant to the Cunard Steamship Co., was largely responsible for the construction of the *Mauretania*. Later presidents, such as Sir Gerard Muntz, Prof. Gowland, Sir Henry Oram (engineer-

in-chief of the Fleet), Dr. Rosenhain (head of the Metallurgy Department of the National Physical Laboratory), Sir George Beilby, Sir John Dewrance, Dr. Desch, Dr. Seligman, are merely typical of those to whom the Institute owes so deep a debt.

This review has not been able to touch on other important aspects of the Institute's work, its publications, for example, other than those of new research. Among these, the successive editions of Prof. W. Hume-Rothery's contribution to our knowledge of atomic theory as applied to alloy systems are outstanding.

It is not surprising, therefore, that, after a comparatively slow start, the membership of this Institute has grown progressively until it now exceeds five thousand, the members being drawn from every country in the world in which a metallurgical industry exists.

F. C. THOMPSON

DISTRIBUTION OF PROFLAVIN-INDUCED MUTATIONS IN THE GENETIC FINE STRUCTURE

By DR. S. BRENNER, PROF. S. BENZER* and MRS. L. BARNETT

Medical Research Council Unit for Molecular Biology, Cavendish Laboratory, Cambridge

THE mutagenic action of 5-bromouracil is highly specific, inducing mutations at points differing from those at which spontaneous mutations most frequently occur. This was demonstrated by Benzer and Freese[1] using genetic mapping techniques of high resolution as applied to the r_{II} genetic region of bacteriophage *T4*. Such specificity suggests the possibility of using various mutagenic substances to probe the chemical nature of the genetic fine structure.

We have investigated mutation in the same genetic material induced by proflavin which had been shown by De Mars[2] to be mutagenic in phage. Proflavin is known to interact with deoxyribonucleic acid but, unlike 5-bromouracil, does not appear to become incorporated. Comparison of the distribution of r_{II} mutations induced by proflavin and by 5-bromouracil shows that these two mutagens act on completely different groups of sites in the genetic structure.

Production of Mutants

Proflavin, although not interfering with synthesis of deoxyribonucleic acid in phage-infected cells, inhibits the maturation of phage progeny particles[3,4]. In order to obtain an infective yield, therefore, the proflavin must be removed before the onset of lysis, thereby limiting the time during which it can be allowed to act as a mutagen. In the present work, we have employed a modified technique which in effect permits the separation in time of genetic replication from the maturation process. If chloramphenicol is added ten minutes after infection, protein synthesis is arrested but phage deoxyribonucleic acid replicas continue to be produced[5]. Brenner and Smith[6] have shown that mutations can be induced in the deoxyribonucleic acid formed under these conditions. When the chloramphenicol is removed, mature phage particles begin to form and cell lysis proceeds. We have made use of this finding to maximize the induction of mutation with proflavin.

A stock of *T4Br+* with a low proportion of spontaneous *r* mutants was selected from among several stocks grown from small inocula. This stock contained one *r* plaque among 19,000 plaques examined. *E. coli*, strain *B*, was grown in glucose-salts medium to 2×10^8 cells/ml. To 10 ml. of this culture was added proflavin to a final concentration of 4 μgm./ml., and 2×10^8 particles of *T4*. After ten minutes of incubation at 37° C., 20 μgm./ml. chloramphenicol was added and incubation continued for one hour. During this period, samples were removed at fifteen-minute intervals, diluted five thousand-fold in glucose–salts medium, titrated for infective centres and incubated for one hour. These experiments showed that during chloramphenicol growth, the infective centres decreased by a factor of four, the average burst size decreased from 200 to 20, and the frequency of *r* mutants among the progeny rose from 0·1 to 0·5 per cent.

Mutants were isolated in two ways:

(1) After one hour in chloramphenicol, the culture was diluted in glucose–salts medium to contain 500 infected cells per ml. and 0·2 ml. dispensed into each of many tubes, which were then incubated for one hour. The contents of each tube were plated on *E. coli B* and 42 independent *r* mutants were isolated, picking one *r* mutant from each tube. The proportion of *r* mutants among the progeny was 0·5 per cent, which represents an increase of about 30-fold over the spontaneous mutation-rate (that is, without proflavin).

(2) After one hour in chloramphenicol, aliquots of the culture were diluted and plated immediately on *E. coli B*. The plaques on these plates arose from infected cells, and the presence of an *r* mutant in the burst from a cell could be noted by the mottled appearance of the plaque. 48 independent *r* mutants were isolated from separate mottled plaques.

In the genetic analysis which follows, there was no apparent difference in the mutants isolated by these two procedures.

Genetic Mapping of the Mutants

The procedure for mapping the proflavin-induced mutations within the r_{II} region of phage *T4* was the same as that previously described by Benzer and Freese[1]. In brief, the steps were: (1) the r_{II} mutants were chosen by their defective growth in *E. coli*, strain *K*; (2) the mutations were assigned to segments of the region by crossing them with a special set of r_{II} mutants which define these segments; (3) the mutants in a given segment were then crossed

* Senior Research Fellow of the National Science Foundation. Present address: Department of Biological Sciences, Purdue University, Lafayette, Indiana.

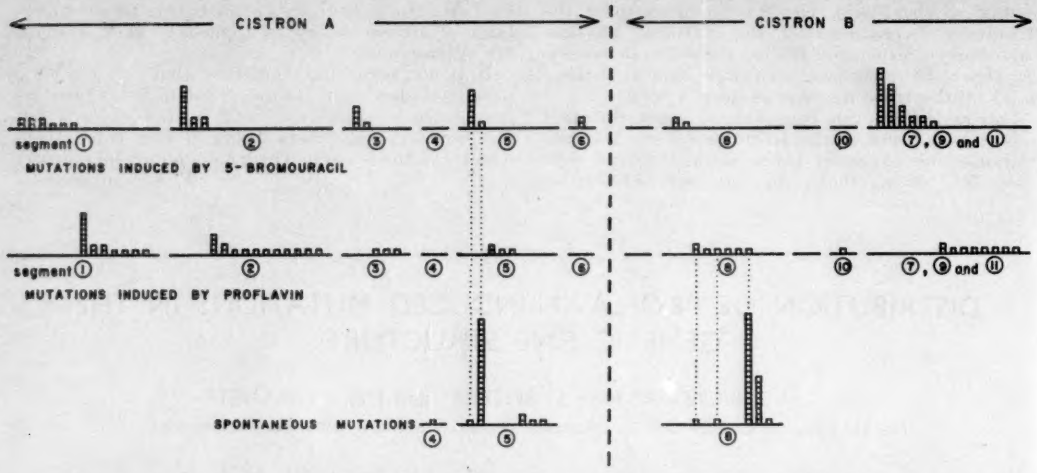


Fig. 1. Genetic maps showing the locations of mutation in the *r*II region of phage *T*4. Each mutation is represented by a box placed in the proper segment of the map. The relative order of segments 1, 2, 3, 4, 5, 6, 8 and 10 is established, but segments 7, 9 and 11 are lumped together and considered as one segment. Within each segment the mutations are arranged only according to whether they fall at the same or at different sites, without regard to their relative positions in the genetic structure. The comparison of spontaneous mutants with the two sets of induced ones is only given for segments 4, 5, 8. (The overall mutation rate is different in each case. The occurrence at a given location of one mutation in the bromouracil set corresponds to roughly 10^2 times higher mutability at that spot than one occurring in the spontaneous set. In the case of proflavin this factor is of the order of 10^3)

with each other to determine which mutations have different locations. The mutations induced by proflavin were then compared with those induced by 5-bromouracil, by crossing a mutant from each of the proflavin sites in a given segment with one from each 5-bromouracil site in the same segment.

Results

Of the 90 proflavin-induced *r* mutants, 58 were defective in growth on strain *K*, and were therefore assigned to the r_{II} group. 3 of these r_{II} mutants were not definitely mapped, one had a high reversion-rate and two were complex (possibly double mutants) and require further investigation.

The reversion-rates of proflavin-induced r_{II} mutants are generally quite low. Of the 58 mutants all except two were sufficiently stable that stocks of them contained less than the order of 10^{-6} revertants. In this respect, mutants induced by proflavin resemble those induced by 5-bromouracil. By contrast, many spontaneous mutants have high reversion-rates.

The results of mapping the 55 r_{II} mutants induced by proflavin are shown in Fig. 1. In this map, mutations are indicated as being only at the same or at different sites and the relative locations of mutations within a segment have not been determined. To facilitate the comparison of spectra with the bromouracil spectrum found by Benzer and Freese the sites in each segment have been plotted in order of decreasing mutability for each mutagen.

The comparison of the induced spectra with that of spontaneously arising r_{II} mutants has been made for segments 4, 5 and 8, which contain the major spontaneous 'hot spots'. As is evident from the figure, these sites do not appear as 'hot spots' in either of the induced spectra. Therefore, proflavin like bromouracil does not simply raise the overall mutation-rate but acts at specific, though numerous, sites.

A few of the sites in the induced spectra coincide with the sites of spontaneous mutation. Some of these coincidences can be ascribed to a background of spontaneous mutants to be expected in the induced sets, since the mutagens raised the overall mutation-rate only by a factor of 30 in the case of proflavin and 100 in bromouracil. Other coincidences may represent true increases of mutation-rate produced by the mutagen at a spontaneous site.

A remarkable feature in the comparison of the bromouracil- and proflavin-induced mutation is that each mutagen appears to act on a set of sites quite distinct from the other. Were the spectra similar, about half the mutations induced by proflavin should have occurred at sites already induced in the bromouracil spectrum. The absence of any coincidences is therefore highly significant.

It is interesting also to examine the distribution of recurrences within each spectrum, as shown in Fig. 2. In the case of proflavin, the existence of single occurrences at many sites implies that there remain additional sites at which no occurrence has yet been observed. An estimate of the number of such sites may be made as follows: assuming a set of sites of equal mutability, the number of occurrences at each of these sites should follow a Poisson distribution, so that the number of sites with zero occurrence can be computed from the ratio of the number with two-fold to the number with single occurrences. The data would then indicate that there exist 96 proflavin sites not yet indicated on the map. This is, of course, a minimum estimate, since there may exist as well many additional sites of lower mutability. Clearly, therefore, the proflavin map shown in Fig. 1 is far from exhaustive.

The distribution for bromouracil appears bimodal. There are four spots of very high (and possibly identical) mutability; it is very unlikely that any additional sites of comparable mutability could have failed to be indicated. Even among the less mutable sites, the ratio of two-fold to single occurrences suggests that only a few comparable sites are not yet indicated.

Although the mutagenic effects of proflavin have been studied in many organisms (bacteria[7], yeasts[8],

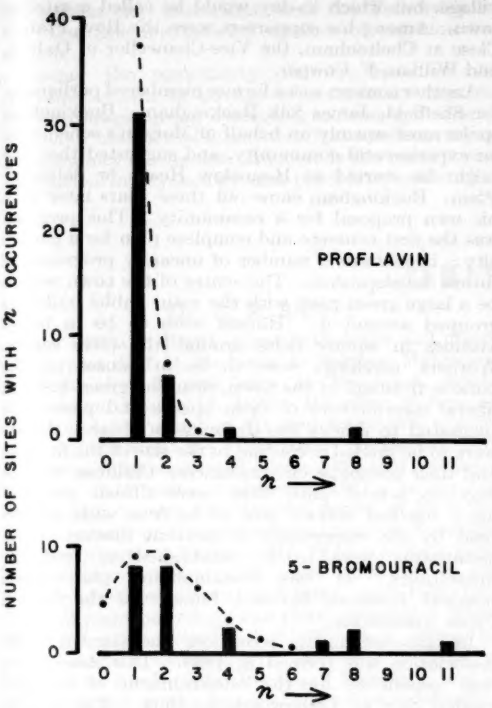


Fig. 2. Distribution of mutation over the various sites induced by proflavin and bromouracil. The dotted line in each case shows the Poisson distribution computed from the ratio of sites with two-fold occurrence to sites with single occurrences

bacteriophage[2] and polio virus[9]) the mechanism of its action is unknown. Unlike bromouracil, proflavin does not appear to be incorporated into deoxyribonucleic acid. Astrachan and Volkin[10] compared bacteriophage deoxyribonucleic acid with that produced in the presence of proflavin. They found some differences between heat-degraded samples, but the significance of this is unclear. Deoxyribonuclease digests, however, were similar, indicating that proflavin did not produce extensive modifications of nucleotide composition or sequences. Proflavin and related acridine dyes are known to form complexes with nucleic acids[11]. Steiner and Beers[12] showed that the combination between polyadenylic acid and acridine orange (the tetramethyl derivative of proflavin) involves interaction between the dye and the adenine ring. The dye does not interact in this way with deoxyribonucleic acid, presumably because adenine is rendered unavailable by hydrogen bonding with thymine nucleotides. Instead, it combines with the phosphate groups[13]. During replication, however, deoxyribonucleic acid may have a configuration in which the nucleotide residues become available to the acridine dye. Such interaction may then be responsible for producing mutations.

The contrast between the three mutational spectra underlines the complexity of the genetic fine structure. A cistron evidently is composed of a large number of mutable elements of several kinds. It should be fascinating to relate these local details to the precise chemical constitution of the genetic structure, but without further knowledge of the chemical mechanisms of mutagenesis this is not yet feasible.

[1] Benzer, S., and Freese, E., *Proc. U.S. Nat. Acad. Sci.*, **44**, 112 (1958).
[2] de Mars, R. I., *Nature*, **172**, 964 (1953).
[3] Foster, R. A. C., *J. Bact.*, **56**, 795 (1948).
[4] de Mars, R. I., Luria, S. E., Fisher, H., and Levinthal, C., *Ann. Inst. Pasteur*, **84**, 113 (1953).
[5] Hershey, A. D., and Melechen, N. E., *Virology*, **3**, 207 (1957).
[6] Brenner, S., and Smith, J. D. (unpublished).
[7] Witkin, E. M., Cold Spring Harbor Symp. Quant. Biol., **12**, 256 (1947).
[8] Ephrussi, B., in Unités biologiques douées de continuité génétique. Colloques Internationaux du C.N.R.S. (1948).
[9] Dulbecco, R., and Vogt, M., *Virology*, **5**, 236 (1958).
[10] Astrachan, L., and Volkin, E., *J. Amer. Chem. Soc.*, **79**, 130 (1957).
[11] Shooter, K. V., "Progress in Biophysics", **8**, 309 (1957).
[12] Steiner, R. F., and Beers, R. F., *Science*, **127**, 335 (1958).
[13] Beers, R. F., Hendley, D. D., and Steiner, R. F., *Nature*, **182**, 242 (1958).

UTOPIAN EDUCATION

TO commemorate the period when that great nineteenth-century educationist, C. J. Vaughan, was vicar of Doncaster—later he became Master of the Temple and, then, Dean of Llandaff—an annual lecture is delivered in Doncaster Grammar School, which itself owes so much to Vaughan's interest and influence.

The lecturer in 1958 was Prof. W. H. G. Armytage, professor of education in the University of Sheffield, who examined the Utopist tradition in English education*. The name 'Utopians' has been invested with associations of eccentricity and futility. Marx and Engels began the process when they described the Utopians as "fanatical and superstitious" and "pedants", and as "promoters of duodecimo editions of the new Jerusalem". Sidney Webb accused them of having too little faith in human nature, and confessed that they seemed to him to be "throwing up the sponge in despair". Arnold Toynbee allows that "the utmost to which all Utopians aspire is to arrest a downward movement".

The historical Jesus, when talking of the Kingdom of Heaven, gave the Utopians their charter. For, as they read it, the Kingdom was not to be a Church Militant, but a real community bound by love and not by law. Not until the time of Sir Thomas More did the Utopian get his programme. For More's "Utopia" virtually idealized a community. More also brought physical science within the compass of the community.

This was an important accretion to the tradition. Science began to be regarded, and especially by Francis Bacon, as the instrument by which the evil consequent upon the Fall could be expunged. Bacon insisted that material progress could not bring happiness without love, and love was ineffective without power. This power lay through inventions, and, as Bacon looked at history, he saw each invention as a guarantee of truth and the effectiveness of

* The Utopist Tradition in English Education. By Prof. W. H. G. Armytage. (Sixth Vaughan Memorial Lecture.) Pp. 16. (Doncaster: Doncaster Grammar School, 1958.) 1*s.* 3*d.*

science. Like St. Paul, Bacon believed that philosophy should produce works. He disliked classical philosophy because it committed the sin of trying to conjure the knowledge of Nature out of the mind rather than out of Nature itself.

Bacon is a modern prophet. He inspired not only J. V. Andreae's "Reipublicae Christianopolitanae Descriptio" (1619) and the Jesuit Campanella's "Civitas Solis" (1623), but also the founding of the Royal Society in England.

The Utopians were building up a tradition of their own. Andreae had a great influence in England. Among the leaders of a group which worked to establish a *societas christiana* were Samuel Hartlib, John Dury and John Amos Comenius. They believed that it was the essential preliminary of the Christian society that a system of universal schools should come into operation to teach all men all things. Hartlib worked to establish a university in London in which there should be taught the scientific principles of trades, like glass-working and metallurgy. Comenius, unfortunately, could not go ahead with his scheme for establishing a college at Chelsea. But the idea persisted, in the Royal Society, and comes down to us virtually undimmed in intensity. Perhaps its best twentieth-century exponent was H. G. Wells, who acted as an evangelist for science.

Much of modern Utopist thought can be discovered in the literary genre known as science fiction. There is another and more important aspect of Utopist endeavour which is almost entirely forgotten. This is the story of those who tried to form communities. The Quakers are pre-eminently communitarian in their approach to religion and education. It was a quartet of Quakers who backed the second great English Utopian, Robert Owen, when he purchased his father-in-law's factory in 1813 to carry out his experiment on the formation of character at New Lanark. The established Church took umbrage at the environmentalist nature of his creed. There was, however, one member of the Established Church who believed in Owen's idea of the regenerative power of community life. This was John Minter Morgan, who is a good embodiment of the Utopist mentality. He was a philanthropist with a private income, and in 1826 he published a book called "The Revolt of the Bees". It was the story of a hive that went through five revolutions, from "noble savagery", through "pastoral occupations", "farming" and "industry", to a fifth revolution pioneered by "the wise bee" (Owen). After this fifth revolution all benefited from a redistribution of the fruits of wealth and knowledge. The "practical and durable form" was for communities to be built surrounded by parks and gardens, to house 1,000 families. The interesting point about Morgan's suggestion was that those who did not live in communities would be able to use the churches as community centres. He envisaged the churches being open on work-days and evenings for lectures and general community activities. This plan was put into operation in Sheffield two years ago with the establishment of St. Mary's Community Centre at Bramall Lane. Morgan, like Owen, envisaged education as the instrument whereby the general level of the population could be raised. In 1833 he urged the authorities of the newly founded University of London to establish a chair of education; this is the first direct proposal for such a chair in England.

In the 1840's Morgan formed a group to secure the establishment of what he called a self-supporting village, but which to-day would be called a satellite town. Among his supporters were the Rev. Francis Close at Cheltenham, the Vice-Chancellor of Oxford, and William F. Cowper.

Another convert was a former member of parliament for Sheffield, James Silk Buckingham. Buckingham spoke most warmly on behalf of Morgan's scheme for an experimental community, and suggested that one might be started at Hounslow Heath or Salisbury Plain. Buckingham came out three years later with his own proposal for a community. This proposal was the first concrete and complete plan for a garden city; it contains a number of uncanny prognoses of future developments. The centre of the town was to be a large green park with the main public buildings grouped around it. Houses were to be in broad avenues in square belts around the civic centre. Workers' dwellings were to be in houses on the outside frontage of the town, near the green belt. A liberal intermixture of open spaces and parks was suggested to relieve the drabness of these. Houses were to be graded according to the size of the families and their economic circumstances. Children were to stay at school until they were fifteen years of age; medical service was to be free, with doctors paid by the community to prevent disease. Civic restaurants were to be established to feed the inhabitants. It was Buckingham's plan which inspired Ebenezer Howard, founder of the Garden Cities Association.

In spite of hostile reception, the Garden Cities Association was formed in 1899. This Association was responsible for the establishment of the first garden city at Letchworth in 1903. The Garden Cities Association helped in the development of garden suburbs at Hampstead, Warrington, Hull, Bristol, Cardiff, Manchester, Rosyth, Liverpool, Ruislip, Bolton, Rochdale and Woodlands, near Doncaster.

The climate of opinion which nourished the Garden Cities Association also produced the Fellowship of the New Life, an informal group founded in Chelsea in 1882 by Thomas Davidson; members of the society were required to lead a higher life. It was a difference of opinion over the formation of a community in England which led some of the Fellowship to separate from the parent body and form the Fabian Society. The secretary of the Fellowship was Ramsay MacDonald, and its main activities were promoting not so much experimental communities as experimental schools. The first Fellowship school was founded at Abbotsholme in Staffordshire. "All schools," insisted the Fellowship's journal, *Seedtime*, "ought to be communities, miniature commonwealth or states, as they were in the Middle Ages. How otherwise can they impart the preparation necessary for adult life?" It was a secession from Abbotsholme that led to the foundation of the second experimental school, Bedales, near Haywards Heath. The third school which sprang from the Fellowship and the Garden Cities Association was St. Christopher School, Letchworth. Just as Abbotsholme threw off Bedales, so St. Christopher School threw off Frensham Heights School at Farnham in Surrey. Both St. Christopher School and Frensham Heights aimed at affording the fullest possible community life of work and play. Another outpost of Letchworth was the Mansfield House Settlement in London.

The Utopists, laughed at and despised in their day and age, have not been without their effect on history. Bacon was the real father of the Royal Society, the Owenite socialists were the fathers of

the garden city movement, and the Fellowship of the New Life incubated a number of experimental schools.

To-day the community planners have a real relevance. This is an age of community centres, satellite towns, group dynamics, sociometry. One of the major intellectual attractions is the rediscovery of a community of Essenes. Another is the current preoccupation in psychology and psychiatry with what is called group therapy. Sociologists, too, are affected: Pitirim Sorokin has established at Harvard a Research Centre in Social Altruism. The Christian Church itself has acquired an enhanced awareness of the importance of community relationships. Utopian literature is well known; what is not so well known are the literary by-products of Utopist endeavour. One is "The Pilgrim's Progress" and another is "The Vicar of Wakefield".

OBITUARY

Dr. G. R. Bisby

GUY RICHARD BISBY, plant pathologist and mycologist, who died at his home in Staines, Middlesex, on September 3, was born at Brookings, South Dakota, on August 17, 1889. He came of farming stock, and like many of his contemporaries worked his way through the university, graduating B.S. from South Dakota State College, 1912, and becoming an M.A. of Columbia University, 1917. In the following year he was awarded the degree of Ph.D. by the University of Minnesota for a thesis on *Fusarium* diseases of potato. During 1916–20 he was instructor, then assistant professor in plant pathology in the University of Minnesota, and later, until 1936, professor of plant pathology and plant pathologist in the Manitoba Agricultural College, Winnipeg (where he took Canadian nationality). He spent 1921–22 in England at the Imperial Bureau of Mycology, and in 1937 returned to the Imperial (now Commonwealth) Mycological Institute, Kew, where he became senior assistant mycologist—a post he held until his retirement in 1954.

The author of more than a hundred books and papers on plant pathology and mycology, Dr. Bisby is best remembered as a taxonomist. His strength in this field was an ability to make up his mind, and this, combined with a systematic approach and prodigious industry, gave him the knack of bringing to a conclusion any project on which he might engage. In a notable series of collaborations he set the pace and brought to fruition catalogues of the fungi of Manitoba, India and Ceylon, lists of the Pyrenomycetes, Hyphomycetes and rusts of Great Britain, and a "Dictionary of the Fungi".

He was interested in many different groups of fungi, and although he will be perhaps particularly remembered for his studies on the Hysteriales, he made important contributions to our knowledge of the Hyphomycetes, especially *Stachybotrys* and *Trichoderma*. He was in charge of the rust collections at the Commonwealth Mycological Institute, and his ready help in identifying specimens and his prompt replies to inquiries will be remembered with gratitude by many overseas plant pathologists. One result of Dr. Bisby's interests in nomenclature was the most useful little book, "The Taxonomy and Nomenclature of Fungi", 1945 (2nd edition, 1953).

Of a retiring disposition, Bisby was seen at his best talking 'shop' in his room at the Institute or in his garden (which was as well-ordered and as weed-free as his taxonomy); but he had many interests, including chess, archæology, the clarinet and, like many taxonomists, stamp collecting. One of his chief hobbies, due in part to a wide circle of friends in North America, was correspondence, and many mycologists welcomed the sight of his clear handwriting and the signature written with such dash and flourish.

Dr. Bisby received a number of honours. He was vice-president of the British Mycological Society, a member emeritus of the American Phytopathological Society, and in 1956 the University of Minnesota awarded him the gold medal for outstanding achievements.

G. C. AINSWORTH

NEWS and VIEWS

The Woodrow Wilson National Fellowship Foundation

SIR HUGH TAYLOR, dean emeritus of the Graduate School of Princeton University, has been appointed first president of the Woodrow Wilson National Fellowship Foundation. Dr. Hans Rosenhaupt, assistant provost of Columbia University, has been appointed national director of the Foundation. The headquarters of the Foundation are at 32 Nassau Street, Princeton, New Jersey.

The Woodrow Wilson National Fellowship Foundation was founded in 1957 with the main objective of recruiting outstanding students for careers as college teachers. In 1957, after the Wilson Fellowships had been jointly underwritten for five years by thirty-seven American universities and by grants from the Carnegie Corporation and General Education Board, the present programme began with a grant of 24,500,000 dollars from the Ford Foundation for a five-year period. During the first year of its operation the Foundation granted fellowships to nearly a thousand students in the United States and Canada who will graduate this year.

H. W. M. Olbers

HEINRICH WILHELM MATTHIAS OLBERS, who was born at Arbergen, a village on the Weser near Bremen, two centuries ago on October 11, 1758, was an amateur astronomer who, even after his discoveries had been accepted and acclaimed, continued his medical practice. The son of a minister, he studied mathematics and medicine at the University of Göttingen, where he graduated M.D. in 1780 with a thesis entitled "De oculi mutationibus internis". While still a student, he devised the first satisfactory method of calculating the orbit of a comet in 1779.

His "Abhandlungen über die leichteste und bequemste Methode die Bahn eines Kometen zu berechnen", with a table of eighty-seven calculated orbits, which was made public by Baron F. X. von Zach in 1797, won him universal fame. A second edition was issued in 1847 and a third in 1864. Olbers took up medical practice at Bremen in 1781, but devoted the greater part of each night to astronomy, having fitted the upper portion of his house as an observatory. On January 1, 1802, he rediscovered Ceres, the first minor planet discovered by Giuseppe Piazzi in 1801, and on March 28 observed the second asteroid Pallas, followed by Vesta in 1807. His theory that these planetoids are fragments of a quondam planet, disrupted by internal explosion or by the impact of a comet, was sanctioned by William Herschel, but is no longer accepted. In 1815, Olbers discovered a new comet which bears his name and which has a period of 74 years. He showed that the tail of a comet consists of a filmy vapour driven off from the head by a repulsive force in the Sun, which is now known to be the pressure of solar radiation. He retired from medical practice on January 1, 1823, and in 1830, the jubilee of his graduation, he received an honorary doctorate from the medical faculties of Berlin, Bonn and Copenhagen. He died on March 2, 1840, in his eighty-second year.

World Data Centre for Rockets and Satellites, Slough

A World Data Centre for Rockets and Satellites is now operating at the Radio Research Station of the Department of Scientific and Industrial Research at Ditton Park, Slough, Bucks. This is the third of three centres established under the International Geophysical Year arrangements for centralization of this type of information. Previously there have been rocket and satellite data centres only in Moscow and Washington, and it was agreed at the recent Moscow meeting of the Special Committee for the International Geophysical Year to accept a British offer of a third rocket and satellite centre. The Radio Research Station is an appropriate place for such centres because many satellite experiments are concerned with studies of the ionosphere. Studying the travel of radio waves from satellite transmitters is one way of gaining information about the ionosphere. Research workers at the Radio Research Station and its Singapore sub-station are engaged in such work. Data from the British investigations will be collected by the Slough Data Centre and exchanged with the other data centres in the United States and the U.S.S.R. Information on International Geophysical Year rocket flights and the published reports of investigations will also be collected. All data will be available for inspection and use by workers in the respective scientific subjects under arrangements which apply to all world data centres.

Reorganization of the Admiralty Material Departments

The First Lord of the Admiralty announced in the House of Lords on December 19, 1957, a reorganization of the Material Departments under the Controller of the Navy, following upon the report of Sir Barclay Nihill's Committee. The reorganization was completed on October 1 when the new Ship Department was set up. The work of the Controller's departments will then have been reorganized into four large material departments (concerned, respectively, with ships, weapons, aircraft, dockyards and maintenance), each headed by a director-general, and a small group of scientific departments headed by the Chief of the Royal Naval Scientific Service, who will work under the immediate guidance of the Deputy Controller (Research and Development). This group is broadly responsible for basic research and development, the provision of scientific staff and advice to the material departments, and the planning and co-ordination of Admiralty research programmes. Applied research and development will continue to be carried out at the various scientific establishments. The superintendents of those establishments, which will form a part of the supporting services of the new Ship Department, will be responsible for the work of their respective establishments to the Director General, Ships, through the directors of the appropriate professional divisions. The senior scientific officer serving in the Department will act as chief scientific adviser to the Director General and to the directors of Divisions.

B.B.C. Television

An interesting addition to the publications of the British Broadcasting Corporation is a booklet entitled "B.B.C. Television—a British Engineering Achievement" (pp. 64. London: B.B.C., 1958. 2*s*. 6*d*.). This is a very well produced and copiously illustrated review of the development and present attainments of the Corporation's television service. Reference is made to the early experimental transmissions begun in 1929, and to the report of the Postmaster-General's Television Committee issued in January 1935, which was followed by the opening of the first public television service in the world during the succeeding year. A brief outline of the principles of television is followed by an up-to-date picture of the television facilities which have been built up and are now in use by the B.B.C., with a full description of the new Television Centre now under construction near Shepherd's Bush. A map in colour showing how B.B.C. television broadcasts reach more than 98 per cent of the population, and advice on how to get the best reception of the B.B.C. television service are other items in this booklet. The effects of various forms of interference are also described and illustrated. A mobile television control room is illustrated together with the various methods of telerecording, including the most recent 'vision electronic recording apparatus' (VERA) which will shortly be put into general service. Outside broadcasts account for approximately one-sixth of the B.B.C.'s television programme output. Apart from dealing with activities in Britain, an account of the growth of the international exchange of television programmes known as Eurovision, which was pioneered by the B.B.C. and Radio Diffusion Télévision Française, is supplemented by a map showing the Eurovision network.

Electronics, Radio and Telecommunications

Considerable progress is being made in the publication of English translations of Russian scientific and technical literature. Three journals have recently become available published in English translation on the initiative of the Massachusetts Institute of Technology and the Pergamon Institute, assisted by a grant-in-aid from the United States National Science Foundation. One of these is *Telecommunications* (No. 1, 1957. Pp. 1–94. First English issue. Issued in parts, approximately 1,000 pages per annum. Annual subscriptions: to individuals, 15 dollars

(107*s.*); to libraries, research laboratories, Government departments and industrial organizations, 30 dollars (214*s.*). New York and London: Pergamon Press, 1958). The first issue contains a number of articles on various aspects of radio and line telegraph and telephone matters. It also includes a brief review of the characteristics of U.S.S.R. State television standard for black-and-white television broadcasting on a 625-line system.

The other two journals appear to be longer established. *Radio Engineering and Electronics* (2, No. 2, 1957. English edition. Pp. 1–183. Approximately 2,500 pages per annum. Annual subscriptions: to individuals, 22.50 dollars (160*s.*); to libraries, research laboratories, Government departments and industrial organizations, 45 dollars (320*s.*). New York and London: Pergamon Press, 1958) contains fourteen articles related to various subjects in electronics, including wave-guides, dielectrics and cathode-ray tubes. A brief article on the life and work of Heinrich Hertz, in relation to the centenary of his birth (February 22, 1857), is also included. *Radio Engineering* (12, No. 8, 1957. First English issue. Pp. 1–112. Approximately 2,500 pages per annum. Annual subscriptions: to individuals, 22.50 dollars (160*s.*); to libraries, research laboratories, Government departments and industrial organizations, 45 dollars (320*s.*). New York and London: Pergamon Press, 1958) is devoted to technical and theoretical aspects of the subject of its title, and is the official publication of the A. S. Popov Technical Society of Radio Engineering and Telecommunications.

Coryndon Memorial Museum, Nairobi

It is pleasing to note that the annual report for 1957 of the Coryndon Memorial Museum at Nairobi makes no reference to any restrictions on its work by Mau Mau activities (pp. 28+1 plate. 1958. Nairobi: Museums Trustees of Kenya and the Coryndon Memorial Museum). Instead, the whole energy of the staff has been turned to constructive measures, and several new exhibits have been prepared. The Bongo habitat group has been enlarged and new groups depicting Abbot's Duiker and Klipspringer installed. Exhibits dealing with the bats of East Africa, melanism and albinism proved popular. Additional marine and freshwater fish were shown in the aquaria, the most outstanding being a young shark and several species of dragon fish. In the Gandhi Hall the mineral and rock exhibits were augmented, many new geological maps were displayed and a new exhibit dealing with recent discoveries at Olduvai Gorge was placed on view. Stamps and postal literature have now been included in the collections.

Forestry in Ulster

An illustrated pamphlet, "Forestry in Northern Ireland" (pp. 20. Belfast: Ministry of Agriculture, 1958), which includes a map of these forests, issued by the Ministry of Agriculture, Northern Ireland, appears to be admirably designed to serve its purpose as a piece of public relations policy. It sets forth clearly and concisely the origin and development of the State forests, the purpose they serve and the policy pursued in their management. At the same time, it indicates their need of public understanding and support, as well as the nature of that support and the contribution to public amenity and enjoyment which the forest parks now offer. A regulation made under the Forestry Act (Northern Ireland), 1953, declared Tollymore Park, near Newcastle, County Down, open to the public as a forest park, and the Park, which covers about 1,200 acres, was officially opened on June 2, 1955.

Careers in the Plastics Industry

Under the title "Careers in Plastics" (pp. 20. London: The Plastics Institute, London, 1958), the Plastics Institute has issued, for the guidance of senior scholars and those responsible for advising them on the choice of a career, a pamphlet setting forth the opportunities presented by the rapidly growing plastics industry, particularly for those with technical qualifications or scientific training. Besides a summary of the technical appointments available, the pamphlet includes information on the constitution of the industry, and particulars of how to enter it, and the technological, professional and academic qualifications desirable (with a chart indicating the various routes by which they may be obtained) and details of teaching centres where approved courses for the qualifications of the Plastics Institute can be pursued. Some indication is given of salaries and prospects, and there is a short appendix on the pupil apprenticeship scheme for the industry, which shows incidentally how well placed a professional body is to press for the adjustment of apprenticeship conditions to meet modern needs.

The National Institute for Research in Dairying

Research workers in many branches of science, practical farmers and agricultural advisory officers will all find something of interest and importance in the annual report of the National Institute for Research in Dairying for 1957 (pp. 160. Shinfield: National Institute for Research in Dairying, University of Reading, 1958. 4*s.*). It is largely devoted to a concise account of the research work done in each of the various departments and sections of which the Institute is composed, while for those who do not require to have so much detail a brief outline is given of many of the recent research findings. The subjects dealt with in the brief outline range from such immediately practical problems as labour-saving devices in feeding lactating sows and grazing management of lactating cows, to basic work such as that on the utilization of amino-acids by the isolated perfused bovine udder and the deoxyribonucleic acid content and histology of the mammary gland. Mention of work done by the Statistical Section on the derivation of general orthogonal polynomials helps to illustrate the breadth of the Institute's programme of work, and in this atomic age perhaps it is not surprising to find that the problem of salvaging milk which has been contaminated with radiostrontium has already been studied. The report gives a detailed list of 151 papers most of which were published in 1957.

The Marshall Pulse Height Analyser *HS* 100

The Marshall pulse height analyser has been developed at the Airport Works of Marshall of Cambridge under licence from the National Research Development Corporation, with the object of producing a first-class British instrument exhibiting all the characteristics of existing analysers at a fraction of the cost but retaining their accuracy and achieving the utmost reliability. This is effected by the use of the Hutchinson–Scarrott principle, using computer techniques for the storage of information performed in serial manner using two torsional acoustic delay lines. This system is inherently simpler in construc-

tion and less extravagant in components than the core memory type of analyser. The facilities include a visual display and automatic read-outs in both analogue and digital systems. The analyser will accept a wide range of pulses of either sign up to a maximum mean counting rate of 1,600 pulses per second. The input pulses may be back-biased at the input to the amplifier, when a gate is provided for coincidence and anti-coincidence work. The memory is divided into either 100 or 150 channels, for which the energy scale may be either linear or exponential, the latter case giving greater resolution at the lower energy end of a spectrum. Another extremely useful facility is the ability of the instrument to subtract counts from a spectrum already in the memory. In conjunction with the live-time integrator, which is necessary at a high counting rate, the background count can automatically be subtracted from a spectrum, leaving the true count in the memory. A total count scaler records the total number of pulses analysed by the instrument. Further information concerning this analyser can be obtained from Messrs. Marshall, The Airport, Cambridge, England.

International Measurements Conference

An International Measurements Conference organized by Hungarian, Polish and Soviet scientific societies is to be held in Budapest during November 24–30. Plenary sessions are to be concerned with papers on the more fundamental matters of units and standards of measurement, together with techniques of measurement and instruments in their broadest aspects. Section meetings are to discuss papers on instruments and measuring methods for: mechanical quantities and precision mechanics; light and colour; temperature, flow, humidity and other process parameters; electrical and magnetic quantities; electronics; physico-chemical quantities; X-rays and nuclear radiations. Papers on economic, organizational and educational aspects of industrial instrumentation comprise a third group. The Proceedings are to be published. During the conference the Hungarian Industrial and Scientific Instruments Exhibition will be open to participants. Further details are obtainable from the Secretariat, Budapest 5, Post Office Box 3.

University News: Birmingham

The following appointments have been made: Dr. Janet S. D. Graham, lecturer in botany; D. P. Howson, lecturer in electrical engineering; B. D. Richardson, lecturer in civil engineering; Sir Francis G. W. Knowles, Bart., and A. W. Rogers, lecturers in anatomy; H. A. Ellis and D. J. Parish, lecturers in pathology; J. D. Cumming, lecturer in physiology.

London

Dr. W. O. James, reader in botany in the University of Oxford, has been appointed University professor of botany and head of the Department in the Imperial College of Science and Technology (see *Nature* of October 4, 1958, p. 916). Mr. H. Charnock, principal scientific officer in the Royal Naval Scientific Service, has been appointed to the readership in physical oceanography tenable at the Imperial College of Science and Technology. Dr. Karl Wilson, lecturer in botany in Birkbeck College, has been appointed to the readership in botany tenable at the College. The title of Henry Mark Pease (Standard) professor of telecommunications in the University of London has been conferred on Dr. E. C. Cherry in respect of his post at the Imperial College of Science and Technology.

Announcements

Sir Rudolph Peters, professor emeritus of biochemistry in the University of Oxford, and lately director of the Agricultural Research Council's Institute of Animal Physiology, Cambridge, has been appointed president of the International Council of Scientific Unions in succession to Dr. Lloyd Berkner.

The Niels Bohr Gold Medal, awarded for outstanding achievement in the field of peaceful uses of atomic energy, was presented to Sir John Cockcroft in Copenhagen on October 7.

Vice-Admiral Sir Frank Mason, formerly Engineer-in-Chief of the Fleet, has been appointed a member of the Council for Scientific and Industrial Research.

Dr. J. G. Malloch, representing Canada, has been appointed chairman of the Executive Council of the Commonwealth Agricultural Bureaux in succession to Mr. T. Swaminathan, who represented India. Mr. A. Perera, representing Ceylon, has succeeded Dr. Malloch as vice-chairman.

Dr. Lewis E. Lloyd, associate professor of nutrition in the Macdonald College of the McGill University, has been awarded the Underwood Fellowship by the Agricultural Research Council, to continue his studies of the metabolism of rumen micro-organisms. For the greater part of the year, Dr. Lloyd will work at the Rowett Research Institute, Aberdeen.

The seventh Coal Science Lecture of the British Coal Utilization Research Association will be given by Sir Charles Goodeve at the Institution of Civil Engineers on October 15. It will be entitled "Carbon: the Key to Metallurgy". Further information can be obtained from the Association at Randalls Road, Leatherhead, Surrey.

A series of lectures by leading experts on space research and technology is being organized by the University of Maryland. The lectures will be held on Monday evenings during October 13–December 1. Further information can be obtained from the Director of Institutes, University of Maryland College of Special and Continuation Studies, College Park, Maryland.

The Journées Métallurgiques d'Automne of the Société Française de Métallurgie will be held in Paris during October 20–25. Further information can be obtained from the Société at 25 Rue de Clichy, Paris 9e.

The next award of the Meldola Medal, which is the gift of the Society of Maccabæans, will be made early in 1959 to the chemist who, being a British subject and less than thirty years of age on December 31, 1958, shows the most promise as indicated by his or her published chemical work brought to the notice of the Council of the Royal Institute of Chemistry, 30 Russell Square, London, W.C.1, before December 31, 1958. Letters of application or recommendation should be accompanied by six copies of a short statement on the candidate's career (date of birth, education and experience, degrees and other qualifications, special awards, etc., with dates) and of a list of titles, with references, of papers or other works published by the candidate, independently or jointly, preferably with one reprint of each published paper of which copies are available.

SCIENTISTS IN THE PUBLIC SERVICE IN BRITAIN

SPECIAL PROMOTIONS

FURTHER special posts have been created in the Civil Service under provisions included in the White Paper on the Scientific Civil Service (Cmd. 6679; 1945) to provide for the promotion of individual research workers of exceptional merit. The promotions, which are effective from July 1, include the following:

Chief Scientific Officer

DR. N. P. ALLEN has been superintendent of the Metallurgy Division at the National Physical Laboratory, Teddington (Department of Scientific and Industrial Research) since 1944. He was a lecturer in the University of Birmingham, where he obtained the degree of D.Sc. in 1934. As a research metallurgist with the Mond Nickel Co., Ltd., he made important contributions to the study of alloy steels and to the development of creep-resistant alloys for gas turbines. At the National Physical Laboratory he has been responsible for work on the metallography of uranium, the brittle fracture of exceptionally pure iron and the influence of additions on it, the development of improved materials for steam power plant and the processes taking place during the fatigue and creep of metals. He has been interested in the metallography of the newer metals such as titanium and niobium, and in the application of radioactive tracers, electron microscopy and soft X-ray spectroscopy to metallurgical problems. He was elected Fellow of the Royal Society in 1956.

Deputy Chief Scientific Officers

DR. I. J. GOOD joined the Government Communications Headquarters in 1941, leaving in 1945 to lecture in mathematics in the University of Manchester. He returned to the Government Communications Headquarters in 1948, and has made notable original contributions to statistical theory and the development of advanced methods of application to Service problems.

MR. H. L. GREEN joined the Physics Section of the Chemical Defence Experimental Establishment in 1922. In January 1949 he was given special promotion on individual merit to the grade of senior principal scientific officer. He has been engaged, and is a recognized authority, on problems related to particulate clouds and filtration, developing many novel devices and techniques for sampling and assessing aerosols and conducting research which has led directly to widely used filter systems including those in respirators. Of late years, he has also been working on problems of radiological defence, including the physics of nuclear fall-out. He has served on Committees of the Department of Scientific and Industrial Research, the Home Office and Medical Research Council and (with W. R. Lane) is author of a recent book, "Particulate Clouds: Dust, Smokes, and Mists".

MR. A. R. HOWELL joined the Royal Aircraft Establishment in 1938. He was a research engineer with Power Jets (Research and Development), Ltd., during 1944–46. On the conversion of the firm he joined the National Gas Turbine Establishment, and since 1949 has been, as a senior principal scientific officer, head of the Aerodynamics Department. Mr. Howell's career has been devoted mainly to the aerodynamics and performance of gas turbines and he is well known for the analysis on which the design rules for the modern axial compressor are based. He has made original contributions on ejectors, theory of aerofoils in cascades, flutter of compressor blades and engine-assisted lift. He is a Fellow of the Royal Aeronautical Society.

DR. J. G. NAGELSCHMIDT, who joined the Safety in Mines Research Establishment in 1949, is a mineralogist of international reputation and is now engaged on research on the mineralogical aspects of pneumoconiosis. He has made important contributions to the study of the toxicity of dusts, as well as in the metallurgical and chemical fields, where he is both an expert and an authority. He has been a pioneer in the application of X-ray diffraction techniques to the study of clay materials, in the application of new mineralogical techniques to the study of dusts responsible for lung disease, and in the application of the electron microscope to the study of clay minerals and dusts. He has developed new techniques for the quantitative mineralogical analysis of small dust samples and for the identification of mineral particles too small for identification with the optical microscope. He is secretary of the Medical Research Council's Sub-Committee on Dust which co-ordinates pneumoconiosis research in Britain; he is a member of the Council's Industrial Pulmonary Diseases Committee, and of its working party on atmospheric pollution. He is also a member of the committee of the Clay Minerals Group of the Mineralogical Society.

MR. J. S. SAWYER, assistant director (dynamical research), joined the Meteorological Office in 1937. He joined the new Forecasting Research Division at Dunstable in 1948, becoming assistant director in 1953. In the past ten years he has made major contributions to the study of rainfall, depressions, the tropopause and the dynamics of fronts, as well as to the revolutionary subject of dynamical forecasting by the numerical integration, using electronic computing aids, of sets of differential equations derived from basic fluid dynamics and thermodynamics. Developments in this promising field are likely to be the main concern of his group for some years to come.

DR. W. S. STILES's original work at the National Physical Laboratory was concerned with problems of vision arising in illuminating engineering, and he did valuable work on glare from car headlights and on street lighting. From these applied problems, he was led to a series of basic studies of the threshold sensitivity of vision under a wide range of stimulus conditions. One outstanding result was the resolution of several mechanisms concerned in colour vision, by

methods independent of the traditional colour-matching approach. Dr. Stiles is probably best known as the discoverer, with his colleague, Dr. B. H. Crawford, of the directional sensitivity of the retina—the Stiles–Crawford effect. Dr. Stiles's investigations during the Second World War of such Service problems as visibility and visual scanning methods was recognized by his appointment in 1946 as O.B.E. Since then he has resumed his investigations of vision, and his latest contribution to the subject is a large-scale determination of average colour-matching properties. In 1957 he was elected Fellow of the Royal Society for his work on vision.

Mr. C. K. Thornhill, joining the Government service in 1939, worked successively at the Projectile Development Establishment, the Ordnance Board and the Armament Research and Development Establishment. In 1952 he was given special promotion on individual merit to senior principal scientific officer. Mr. Thornhill is a versatile applied mathematician. His early research was on the development and lethality of rockets, external and internal ballistics, gun-heating and gun-erosion, and led to the award of the U.S. Medal of Freedom for meritorious service in the Second World War. More recently, he has contributed to several fields of weapons research and has become a recognized authority on steady and unsteady gas dynamics and on explosion phenomena, working particularly of late on the effects of atomic explosions. Mr. Thornhill served on the Compressible Flow Tables Panel of the Aeronautical Research Council, and contributed portions of its well-known published collection of tables and graphs.

Mr. R. A. Wells is in charge of the Radiochemistry Group at the National Chemical Laboratory of the Department of Scientific and Industrial Research. He has played a large part in the foundation of analytical techniques based on chromatography and applied to inorganic materials, now used in Australia, South Africa, Rhodesia, Portugal and Canada. These researches constitute an outstanding achievement in analytical procedures during the past decade. He also devised field techniques for the determination of various metals in river waters. In hydrometallurgical research he has developed new methods for the concentration and extraction of metals, for example thorium, by the use of modified celluloses such as the phosphorylated product; and a series of selective ion-exchange resins whereby gold can be recovered from cyanide liquors. He has on occasions acted as a consultant to the Atomic Energy Authority on flow-sheets and costing in connexion with full-scale industrial uranium-extraction plants.

Senior Principal Scientific Officers

Mr. P. J. E. Forsyth, of the Metallurgy Department, Royal Aircraft Establishment, is a skilled experimenter who has done outstanding work on fundamental aspects of the fatigue of metals and alloys.

Dr. L. Grunberg is engaged in the Lubrication Division at the Mechanical Engineering Research Laboratory of the Department of Scientific and Industrial Research on the chemical and physico-chemical aspects of lubrication in relation to the wear of the rubbing surfaces of machine components. He is distinguished for his work on the study of the emission of charged particles occurring on freshly deformed metal surfaces.

Dr. F. E. Jones is a member of the Chemistry Division at the Building Research Station of the Department of Scientific and Industrial Research, where he has worked on the chemistry of cement and concrete, and in particular on the products formed on hydration; and on the corrosion of metals under the particular conditions that arise in buildings.

Dr. D. McK. Kerslake, of the R.A.F. Institute of Aviation Medicine, is in charge of the Climatir Research Laboratory. His work in recent years hac been mainly directed towards the protection of aircrews against extremes of cabin temperature, and in this particular field he has become well known throughout Britain.

Dr. T. S. Moss, of the Radio Department, Royal Aircraft Establishment, has carried out much original experimental and theoretical work on the properties of semi-conductors and is a leading authority on photo-conductivity and infra-red detection.

Dr. C. A. Parker is head of the general chemistry division at the Admiralty Materials Laboratory, which includes in its programme radiochemistry, X-ray techniques and ferrite chemistry. He is now specializing in photo-chemistry.

Mr. H. H. B. M. Thomas, of the Aerodynamics Department, Royal Aircraft Establishment, is well known as an authority on the stability and control problems of aircraft.

Mr. P. R. Wallis, working at the Admiralty Signal and Research Establishment, has been responsible for much of the development of radar techniques for guided weapon systems.

Dr. Johanna Weber, of the Aerodynamics Department, Royal Aircraft Establishment, has worked on a variety of problems in classical theoretical aerodynamics, including the theory of lifting surfaces in supersonic flow and the minimization of wave drag.

Dr. J. G. Whitman, of the Mechanical Engineering Experimental Establishment, has a wide background of engineering research, especially in problems of welding and of the fatigue and failure of metals and metal structures.

Similar promotions have been made by the Agricultural Research Council, as follows:

Deputy Chief Scientific Officer

Dr. Robert Brown, after graduating with first-class honours at the Imperial College of Science and Technology, London, in 1936, held various teaching appointments. He was a senior lecturer in botany at the University of Leeds during 1946–49, when he became reader in plant physiology. He joined the staff of the Agricultural Research Council in 1953 on his appointment to the directorship of their Unit of Plant Cell Physiology at Oxford. Dr. Brown's researches are principally directed to the cellular phenomena involved in plant growth and differentiation. He has given particular attention to the meristems, analysing development in terms oy cell division and cell expansion. In October 1958 Dr. Brown will become head of the Cell Biology Department of the John Innes Horticultural

Institution. Dr. Brown was elected Fellow of the Royal Society in 1956.

Senior Principal Scientific Officers

Dr. H. F. Barnes is deputy head of the Entomology Department at Rothamsted Experimental Station. He is a world authority on gall midges and he has published widely on these and other insect pests.

Dr. K. L. Blaxter, head of the Nutrition Department of the Hannah Dairy Research Institute, has been particularly concerned with research on problems related to the energy exchange of large farm animals.

Dr. G. A. Levvy is head of the Enzymology Department of the Rowett Research Institute. He is working in the field of the biochemistry of the glycosidases of their inhibition by aldonolactones.

One similar promotion to senior principal scientific officer has been made by the Atomic Energy Authority. Dr. P. E. Cavanagh, who is head of the beta-ray spectrometer group at Harwell, doing mainly basic research but also responsible for some technical developments, including that of the recording of nuclear-pulse data on magnetic tape. Achievements in basic research include the original observation of the double Compton effect—a higher order process in quantum electrodynamics—and the first accurate measurements of electron polarization violating parity.

The Development Commission has similarly promoted Dr. H. Barnes to senior principal scientific officer. Dr. Barnes has been a research chemist on the staff of the Marine Station, Millport, since 1946, and is well known for his work on physical and chemical oceanography. In addition, he has developed underwater television apparatus and is an authority on the biology of barnacles.

OCCUPATIONAL PSYCHOLOGY

AMONG the best-attended meetings in Section J (Psychology) of the British Association this year were those held during the occupational psychology session on September 1. Four papers were given in the course of the morning on which the session was held. Anyone looking for continuity or what the papers had in common might have remarked that the first dealt with competitive entry into industry in youth—trade apprentice selection—while the last dealt with retirement—largely compulsory retirement—from industry because of age. From another point of view there was also a certain similarity between the first three papers. All were, in a sense, directly concerned with problems of inspection; the first, 'inspection' of suitability for trade-apprenticeships in shipbuilding; the second, routine inspection of industrial products; and the third, systems of fault-finding in electronic equipment.

In the first paper, by Mr. J. G. McComisky (University of Hull) and Dr. P. P. Daws (University of Edinburgh), the introduction and development of an apprentice selection scheme in a Glasgow shipyard were described. In 1956, when the firm approached the Applied Psychology Unit of the University of Edinburgh for assistance, only about half the boys put on the firm's pre-apprentice trade courses were reaching the necessary standards to become indentured. In round figures, to obtain its quota of about 80 trade apprentices each year, the firm was obliged to put about twice this number through its pre-apprentice courses. All boys entered on courses were regarded as being likely to succeed. Following a review of the position when the firm asked for assistance, the following programme was decided on: (1) That immediate steps be taken to check the effectiveness of the firm's own system of initial selection. This consisted of an arithmetic test and an interview by the firm's apprentice supervisor. The arithmetic test was checked and found to be faulty. It was discarded and a new arithmetic test introduced. (2) That a selection scheme involving psychological testing be run for an experimental period of one year, and if the results warranted it, that this should replace the firm's existing system of selection. (3) That the selection scheme be developed in a way which would enable the firm's apprentice supervisor to run it with the need for no more than occasional advice and guidance from a psychologist.

Before experimental selection began, all second-year trade apprentices in the firm were given the battery of psychological tests which it was proposed to use during the experimental phase of the scheme, the object being to see what relation there was between scores on the various tests and foremen's assessments of the second-year apprentices. A meeting was also arranged with the instructors on the pre-apprentice courses, the object being to enlist the co-operation of these in the projected scheme right from the beginning, and also to obtain information on the kinds of difficulties met by both instructors and boys on the pre-apprentice courses.

With the information and insights obtained from these sources experimental selection began. This, in practice, entailed giving all the boys on the firm's courses the battery of tests decided on, interviewing each for about 15 minutes, and then predicting whether or not the particular boy was likely to pass the course. An attempt was also made to spot particularly bright boys, as the firm was anxious to put these in line as early as possible for technical advancement in the firm. The degree of success in predicting failures and bright boys in the experimental year was encouraging enough to justify the procedure being put into effect as the official apprentice selection scheme of the firm.

In the first year of actual selection wastage on the courses dropped considerably: on the shipbuilding side—one of the two main divisions of the firm's apprenticeship system—it dropped from 42 to 22 per cent with a reduction of 33 per cent in the number of boys entered on courses. On the marine engineering side, the smaller division of the firm's apprenticeship system, the results were not as good, but the failure-rate in the first year of real selection dropped to

41 from 55 per cent in the previous year with the prospect of being further reduced. Work on improving the scheme is continuing. Dr. Daws, who has been supervising it for the past two years, has just discovered, for example, from his analysis of the relationship between scores on the tests and ability on the pre-apprentice courses, that the combined score of the five most effective tests in the battery—a verbal and a non-verbal intelligence test, a test in spatial ability, one in mechanical comprehension and one in arithmetic-mathematics—forms a most effective predictor when used alone. The refinement and adoption of this predictor will considerably simplify the selection procedure as a whole.

Since the full introduction of the scheme eighteen months ago it has been run by the firm's apprentice supervisor with the advice of Dr. Daws where necessary. In terms of cost the scheme has turned out to be comparatively inexpensive in both time and materials.

In the second paper, Mr. R. M. McKenzie (University of Edinburgh) described some of the factors making for good or bad relations between inspectors in industry and the workmen concerned. Some of the factors described involved considerations which were mainly economic, as, for example, where a bonus is paid only for work which has passed the inspector; other factors derived from the organization of the particular factory and the nature of the product, for example, in 'in-process' inspection where the particular products are checked while they are still being made so that any error of man or machine can be put right before a lot of bad work has been done. A third group of factors originate in the more purely human aspects of inspection, the fact that inspection with the prospect of adverse criticism is going on at all, whether or not the inspector is an older person than the general run of those whose work he is inspecting, what length of service he has had with the particular firm, and so on.

A consideration often discussed in connexion with inspection in industry is the nature of the inspector's qualifications for the job. Since the production man must be able to accept criticism from his inspector without losing face, it is a great help if the inspector is at least as well qualified technically as the operator or the charge-hand. He may, however, not need this skill to do the actual inspection. As Mr. McKenzie pointed out, "Many a man can grade an egg who could never lay one, but the man who grades the eggs can tell which hens are no use".

Another aspect of inspection which Mr. McKenzie dealt with was the frequent accusation that inspectors are inconsistent. A number of experiments which he himself had carried out showed that there is more to this criticism than an attempt to save face. In an experiment, for example, in checking sub-assemblies, one inspector rejected five out of a batch of fifty in one day but nine in the next. Another inspector rejected thirteen of the same batch. Two inspection-supervisors, as judges, considered that, in fact, eight were defective. The results of Mr. McKenzie's experiments indicate clearly that the consistency of inspectors should not just be taken for granted. Factors which work against consistency include the fact that very often standards have simply not been clearly laid down. Often, too, the training of inspectors could be improved. Sometimes physical conditions such as the placing of lights or even the boredom of repetitive inspection are factors in poor consistency. It might be asked: Why do not inspector-supervisors check the accuracy of their inspectors? The reason, in practice, is usually found to be that very often relations with production are strained, and, as a consequence, the inspector-supervisor tends to side with his inspectors. The result is that he sees himself first as an inspector and only very secondarily as a supervisor over inspectors.

In his summing up, Mr. McKenzie stressed the importance when picking inspectors of paying particular attention to whether or not they are likely to be acceptable to those over whom they are exercising authority. This is quite crucial since inspection is not just of the product but of the man who has made it; because of this a reasonable working relationship must be established between the two sides. The quite anomalous position of the inspector in regard to both authority and pay in industry at the present time makes this all the more imperative. The inspector, for example, is not the workman's supervisor; very often he has only the same rank as the operator himself, and in many cases receives even less pay. This makes a naturally difficult job even more exacting and underlines the need for appreciation of the importance of such qualities as tact and forbearance in the inspector in industry.

In the third paper, Mr. H. C. A. Dale (University of Cambridge) described an experimental programme on method of approach in fault-finding on which he is engaged. Mr. Dale began by pointing out that the overall efficiency of electronic equipment usually depends on the rapidity with which faults can be located and repaired. In other words, a good deal of the maintenance on it is remedial. Actual repair work usually presents no problem, but fault location does, and good fault-finders are in short supply. Mr. Dale's own research on the subject was aimed at determining the best way of training technicians to do fault-finding in an economic way.

Before addressing himself to the specific aspects of the problem, Mr. Dale gave a short description of basic design in electronic equipment as follows: electronic equipment consists basically of units arranged in chains. A signal or message flows through these chains, each unit making a slight change in it, rather like the way in which small changes are made to the product in a mass-production factory. The fault-finder has to search first for the chain which is faulty, then for the faulty unit, and finally for the component within this unit which is causing the trouble.

The question Mr. Dale then asked was: Can we expect persons to know the best way of searching in a system of this kind, or do they have to be taught? In actual location of faults in electronic equipment when done in the most efficient way, three steps are essential: (1) discover which chain is faulty; (2) locate the faulty unit; (3) find, within this unit, the faulty component.

Put briefly, the golden rule is: general questions are asked first, specific ones later. Mr. Dale then described the results of one of his experiments the main object of which was to see how far this systematic kind of fault-finding is adopted in actual practice. First, he set up laboratory fault-finding problems which involved searching in the same way as in the case of actual electronic equipment. In the particular experiment described, no more than six moves were necessary to locate the fault. The task was given to twenty-four subjects. All were thoroughly familiar with the idea of signal flow. Of the twenty-

four, one only used a good solution. Eight of the twenty-four took ten moves or more. The common errors made were to move along in short steps instead of dichotomizing, to check junctions instead of chains, and to go into a chain before first finding if it contained a fault.

After describing the results of this experiment, Mr. Dale went on to tell how he checked his finding against the kind of errors made by electronic engineers searching for real faults in real equipment. The evidence shows that there is a marked tendency to make the same kinds of errors in actual practice. A study carried out by Bryan in the United States, for example, showed that of seventy of the U.S. Navy's best technicians engaged on the maintenance of wireless sets, only 17 per cent of them dichotomized.

Mr. Dale concluded his paper by saying that the results of his experiments to date and those of other relevant studies indicate clearly that we cannot expect electronic engineers to know the best way of searching for faults. They need to be taught, and, it seems, they need to be taught by instructors in technical college, not by experience.

In the last paper of the session Dr. N. R. Cowan, medical officer of health, Rutherglen, Scotland, reported the results of an inquiry into the life-histories and opinions of 443 retired men, aged 65 to 93 years, who attended a Scottish Consultative Health Centre for older people. Approximately 80 per cent of the group had been compulsorily retired. The main purpose of the report on the inquiry given in the paper was to focus attention on the traumatic effect of retirement on the health of older men.

The information for the investigation was obtained from the men on a doctor–patient basis during their visits to the Centre. An analysis of the data showed how far it could be said that the members of the group were leading a 'full' life at the time when the inquiry was made. Three criteria of 'full' were used: physical activities, mental activities, and personal relationships. Each member of the group was given a 'high', 'medium', or 'low' rating on these, and, in addition, a grading for social status based on the occupational classification list of the General Register Office. This ranges through five levels, from class I (professional) to class V (unskilled). The distribution of the group along the five levels inclined towards the lower end: there were 24 in class I (professional) and 83 in class V (unskilled).

The results of the inquiry showed that 'high' ratings on the three criteria of a 'full' life were in no case above 10 per cent for the complete group and that these were found among men in classes I and II. The proportion of 'low' ratings was quite pathetic. In the case of 'mental activities' it was 44 per cent of the group, with 'personal relationships' at 32 per cent. It was apparent that the unskilled workers in the group tended to lead equally unskilled lives.

In the course of the paper Dr. Gowan directed attention to how the harshness of the fact that our economic system does not provide employment for all who wish to work operates to such a deplorable extent against men in the age-group covered in the inquiry. As he pointed out, it is a common occurrence to see older men unsuccessfully seeking work, and also those who have passed through this stage without finding employment, unhappily resigning themselves to retirement. There are, in addition, the partial casualties of compulsory retirement—those who are forced to change their jobs late in life because of age. Of the men in the present group, 79 per cent regarded compulsory retirement as detrimental to the health of older men. One can only agree with Dr. Cowan's suggestion that until society provides some sort of education and preparation for retirement it has a social obligation to provide and subsidize congenial work for those who wish to do it.

This concluded the occupational session. It was a new venture this year in the Psychology Section of the British Association meeting and proved to be a rewarding one.

J. G. McCOMISKY

ANALYTICAL CHEMISTRY, PHARMACY AND MEDICINE

IN his chairman's address to the British Pharmaceutical Conference at Llandudno on September 15, Dr. G. E. Foster, chief analyst of Burroughs, Wellcome and Co., expressed a more than personal pleasure in the election of an analyst to the chair. Such an election, he said, was a recognition of the indispensable services which chemical analysis rendered to pharmaceutical science and industry. The names of Scheele, Baumé and Mohr illustrated how analysis and pharmacy had always, in fact, gone hand-in-hand up to the establishment of 'classical pharmaceutical analysis'—a stage which could perhaps be considered as embodied in the British Pharmacopœia of 1932.

In taking as his title "Modern Analytical Chemistry in the Service of Pharmacy and Medicine", Dr. Foster directed attention to the great pharmaceutical value of 'post-classical' developments in analysis. Developments which made it possible to work on very small amounts of material were of particular value, partly because of the very expensive nature of many modern drugs, and also because of their very high potency, which implied that only small amounts would be present in many preparations. For a number of drugs (adrenaline, atropine, carbachol, vitamin B_{12}, digoxin, ergometrine, stilbœstrol and physostigmine being among the examples quoted) the human dose was only a fraction of a milligram.

Classifying these techniques into microchemical and microbiological, Dr. Foster defined microchemistry as "ordinary chemistry carried out on a small scale", and often with the aid of special instruments. Among these, the microbalance had its place; but it should be remembered that colorimetric methods—whether for actual assay of such drugs as morphine, ergot alkaloids or tubocurarine, or for the estimation of impurities such as trace metals—were also essentially microchemical in nature. The use of the photoelectric spectrophotometer in comparing colours of solutions, reducing error to about $\pm 0{\cdot}1$ per cent as compared with about $\pm 5{\cdot}0$ per cent in visual comparisons, was given as an illustration of the improved sensitivity which instruments could achieve.

Of microbiological assays, Dr. Foster said these had made their way into very wide and intensive use, calling as they did for little more than standard

bacteriological technique and equipment, while effecting great savings of time and expense as compared with experiments on larger animals. Moreover, they could fill the gap when suitable larger subjects were simply unobtainable. Progress in research on the active agents in liver extract had been extremely slow so long as the only subjects known to be suitable for assay were human sufferers from pernicious anæmia. The development of methods measuring the potency of the extracts as growth stimulants for *Lactobacillus* species contributed largely to the identification of folic acid and vitamin B_{12}, while at the same time providing an effective assay.

Microbiological assays were of use for the control of both growth inhibitors (antibiotics and bacteriostatics) and growth promoters (vitamins, etc.). The principles of assessment of the amount of microbial growth from the turbidity of the culture, or from the diameter of the zone of growth promoted or inhibited by diffusion around a spot of the active agent on an inoculated agar plate, were equally useful in either context. For growth inhibitors, serial dilution in order to arrive at the minimal effective dose was also a practical alternative; while for growth promoters, titration of acid liberated in the metabolism of the growing organisms was often the most effective measure of growth.

Successful application of any analytical technique was largely dependent on preliminary isolation of the ingredient sought. In this connexion, Dr. Foster reviewed the group of varied procedures to which the name of 'chromatography' is customarily, though not very perspicuously, applied. Of these, the most universally serviceable is no doubt the solvent partition technique, with paper chromatography as its most usual adaptation. Counter-current solvent extraction, however, might logically be classed as an extreme modification of the same principle. Paper chromatography had been successfully applied in the study of the digitalis glycosides, the identification of the polymixins, the fractionation of liver extract, the separation of the penicillins, and the establishment of the molecular structure of insulin.

Adsorption and ion-exchange chromatography had had more limited though still extensive pharmaceutical uses, especially for isolation of vitamins (for example, D_2 and B_1) before colorimetric determination. Gas–liquid, also known as gas or vapour-phase chromatography, was the most recent arrival, but might well replace analytical distillation, especially for very small amounts of material. It had already been applied to the detection of impurities in Chloroform B.P., and the examination of essential oils seemed an obvious further application.

FORM AND FUNCTION IN THE MOLLUSCA

DURING the meetings of the British Association in Glasgow a session on "Aspects of the Evolution of Form and Function in Molluscs" was held in Section D, those delivering papers being all of them members of the Department of Zoology in the University of Glasgow. In his preliminary remarks, Prof. C. M. Yonge directed attention to the unique features of the Mollusca. The body is primitively bilaterally symmetrical with an antero-posterior axis of growth but over this extends a mantle, attached to the visceral mass and secreting a protective shell, which is initially biradially symmetrical growing by marginal increment. While such conditions continue to exist in the recently discovered monoplacophoran *Neopilina* and in a modified condition (by subdivision or by loss of the shell) in Polyplacophora and Aplacophora, evolution within the Gastropoda, Bivalvia and Cephalopoda represents interaction between the body, essentially head and foot, on one hand, and the mantle and shell on the other. In the Gastropoda a balanced condition often exists, but the mantle may dominate as in the sessile vermetids or it may diminish and disappear as in the opisthobranchs; in the Bivalvia the mantle completely encloses the body and is entirely responsible for external form, so largely controlling habit.

The respiratory chamber of the Mollusca consists of a primitively posterior mantle cavity containing the characteristic gills, paired ctenidia which consist of an axis containing afferent and efferent blood vessels, a branchial nerve and muscles, with rows of filaments alternately disposed on the two sides. Lateral cilia on the filaments set up a respiratory current which flows upward between the filaments within which blood flows in the opposite direction. Supporting rods within the filaments prevent buckling of the delicate tissues; cleansing cilia on marginal surfaces remove particles carried in suspension by the respiratory current.

No organs in the animal kingdom have been more successful or proved more adaptable[1]. With folding of the filamental surfaces and creation of a more powerful respiratory current by pulsations of the funnel and then of the mantle wall, these ctenidia cope with the oxygen needs of modern dibranchiate cephalopods, while with filaments greatly increased in numbers and in individual length they have become organs of feeding in the bivalve Mollusca, the most successful group of ciliary feeders. In the Gastropoda the effect of torsion has been to bring them to the anterior end, and that of asymmetrical coiling of the shell with loss of the marginal slit or apical aperture has been the reduction and loss of the right (post-torsional) ctenidium. In the Mesogastropoda reduction to a single (right) row of filaments on the left ctenidium occurs, but with enhanced efficiency. In the pulmonates the ctenidium is lost but the possibilities inherent in a mantle cavity with vascular walls become apparent, this forming a lung and being possibly the most important factor in colonization of the land and also of freshwaters by Gastropoda.

In the evolution of the Bivalvia[2] the original dome-like shell must have extended marginally and been laterally compressed. The mantle also became attached near to the margin of the shell. The final stage of compression was made possible by reduction of calcification along the mid-line dorsally while at each end there was cross-fusion of the pallial attachments to the shell in the regions of bending. There thus came into simultaneous existence the ligament and the two adductors, the means of opening and of closing the bivalve shell. Complete enclosure of the

body by mantle and shell was accompanied by reduction and final loss of the head, feeding being probably taken over by mobile extensions of the lips, the palp proboscides, as in existing protobranchs, for example, *Nucula*[3]. The ctenidia remained primarily concerned with respiration, but further change produced the filibranch and eulamellibranch ctenidia, which collected food, the function of selection being retained by the palp lamellæ. The sensory functions of the head were taken over by the mantle margins, which consisted of an outer lobe concerned with the primitive function of secretion, a sensory middle lobe bearing tentacles and sometimes, as in *Pecten*, eyes, and an inner muscular lobe which controls the volume and site of the inhalant water current. Fusion of the mantle margins[4], to varying extent but initially always by the inner lobes, led to enclosure of the animal and to the formation of siphons enabling bivalves to burrow or bore deeply and yet retain contact with the water for food and oxygen. By the same means the primary ligament—of inner and outer layers with superficial periostracum—could be extended by secondary formation of a fusion layer representing union of the outer surface of the outer lobe of the mantle margins and particularly well shown in the long secondary extension of the ligament posteriorly in *Pinna*[5].

Following up this theme, G. Owen pointed out that the bivalve shell consists of two valves with a connecting ligament, not of two discrete valves united by a ligament of different origin. He noted that the description, as given by D'Arcy Thompson in "Growth and Form", of the growth lines of each valve as a system of closed co-axial lines is incorrect because the growth lines of the two valves are continuous across the primary ligament. Within the shell, loss of the head has the effect of reducing the anterior portion of the body so that in a simple dimyarian bivalve, such as the modern *Glycymeris*, a line drawn from the mid-point of the body dorsally through the middle of the foot divides the animal into almost equal anterior and posterior regions. This line may be designated the 'median axis'. Corresponding division of the mantle and shell is made by way of a line which, starting at the umbones, follows the zone of greatest convexity which in *Glycymeris* leads it to about the mid-point marginally. This demarcation line may be said to separate the mantle and shell into anterior and posterior territories; when projected on to a plane surface it corresponds almost exactly with the median axis of the body.

The form of the shell of a bivalve[6], neglecting here differences between the valves, depends on the growth gradients around the margin of the mantle. If greatest around the mid-point ventrally a symmetrical equilateral shell is formed as in *Glycymeris*. Where growth is greatest posteriorly the shell becomes elongated as in the razor shells (Solenidae)[7,8]. In these the demarcation line is close to the anterior end, the posterior territory being many times the area of the anterior, but the proportions of the body are *not* affected; although by influence of the form of the mantle and shell now bent into a U, the median axis continues to separate approximately equal anterior and posterior regions. The overall effect is formation of a cylindrical shell with short siphons posteriorly and an elongated foot emerging at the anterior end. This makes possible rapid vertical movements by which these bivalves escape danger from predators or from desiccation.

Elongation caused by centres of growth at each end of the mantle produces, by convergence, deep burrowers such as *Mya* (Myacea), *Lutraria* (Mactracea), *Panope* (Saxacavacea) and *Glauconome* (Veneracea)[6]. In all, the median axis and the demarcation line are little altered but there is great elongation of the fused siphons and great reduction of the foot. These animals are immobile deep burrowers reacting to danger solely by withdrawal of the siphons. A final example may be taken from the Tellinacea where, particularly in *Donax*, there is a tendency for enlargement of the anterior territory while, in correlation with the deposit feeding habit (in distinction to the other genera which are all suspension feeders), the animals have both long separated siphons and a powerful foot which enables them to move horizontally within the substratum.

These represent a few instances in which alterations in the form of the mantle and shell influence that of the body with notable effects on habit. Although impossible to discuss here, the opposite condition may occur with changes in the form of the body (probably always initially associated with byssal fixation) affecting that of the mantle and shell[3].

In his communication, Dr. G. E. Beedham directed initial attention to the fact that the ligament and the valves consist of the same three layers formed by the same means, (1) a superficial horny periostracum secreted by the inner surface of the outer mantle lobe and appearing to issue from a 'periostracal groove' between the outer and middle lobes, (2) an outer calcareous (or ligament) layer formed by the outer surface of the outer mantle lobes and (3) an inner calcareous layer formed by the general inner surface of the mantle, this being modified along the mid-dorsal line to constitute the mantle isthmus which secretes the inner ligament layer[9]. These findings he showed to be strengthened by study of the composition of the non-calcareous material (conchiolin) in the shell of *Anodonta cygnea*[10]. The chemical and histochemical properties of the outer layers of the valves and ligament are very similar. The conchiolin from both regions, and also that of the periostracum and the fusion layer of the ligament with which it is comparable chemically, consist principally of a quinone-tanned protein. Acid hydrolysates of this protein were analysed by paper chromatography and found to be rich in phenolic amino-acids, especially tyrosine, and in glycine.

The conchiolin components of the inner shell layers present a contrast. Hydrolysates contain appreciably more aspartic acid and glutamic acid, but much smaller amounts of tyrosine and glycine. Their protein constituents show only slight signs of tanning. In these properties, the inner layers of the valves and ligament appear basically alike. However, each component has certain peculiar features; acid hydrolysates of the inner ligament layer, for example, are characterized by a high content of proline and of the sulphur-containing amino-acid, methionine. These modifications in the protein of the inner ligament may well be correlated with the highly specialized function of this region of the shell.

The divergence in composition between corresponding layers of the valves and ligament may become more extreme in other bivalves. In *Ostrea edulis* and *Mytilus edulis* the outer layers of the valves and ligament each exhibit progressively greater specialization compared with the situation in *Anodonta*. This is most marked in *Mytilus*, where the

conchiolin in the outer calcareous layer of the valves has almost the same composition as that in the inner layer, and consequently differs completely in character from that in the outer ligament layer. Nevertheless, in both these bivalves, the inner layers of the shell exhibit properties comparable with those of their counterparts in *Anodonta*, similarity between the inner ligament layers being particularly close.

In considering the evolution of Gastropoda in fresh waters, an account was given by Dr. W. Russell Hunter of work largely carried out at the field station maintained on Loch Lomond by the Zoology Department of the University of Glasgow. The snails of fresh waters are either prosobranchs, retaining the typical molluscan ctenidium and closely related to marine gill-breathing forms, or pulmonates with no ctenidium and the mantle cavity modified as a 'lung'. In both groups different degrees of adaptation to life in fresh waters co-exist, forming functional and morphological series. The ecological and physiological work reported upon was largely concerned with certain species of pulmonate snails, including *Lymnaea peregra*, *Physa fontinalis* and *Planorbis albus*. Some populations of these snails have to migrate periodically to the surface of the water to breathe[11]. Other populations of the same species can live in deeper offshore water, and a variety of conditions are found in their mantle cavities. In some the 'lung' is water-filled, the snails respiring by some other means, while in others it contains a gas-bubble, which may be used to obtain dissolved oxygen from the water, or merely to give buoyancy[12]. Similar variations between different populations within each species of snail are found in their reproduction: the breeding periods, the numbers of eggs produced, and the survival of the young vary from one population to another. Adaptive plasticity in their methods of breathing, feeding and reproduction is characteristic of freshwater molluscs as a whole. The process of evolution in animals like snails living in fresh waters has been markedly different from evolution in similar animals living in the sea or on land[13]. Freshwater environments are characterized by the high degree of small-scale, short-term isolation which can occur within them. Thus, it seems likely that both the adaptive plasticity found in several aspects of the physiology of freshwater snails, and the co-existence of different degrees of adaptation to limnic life, are associated with the discontinuity in space and the impermanence in time of most fresh waters[13].

A. E. Henderson described his experimental work on the mantle cavity mainly of the larger freshwater pulmonates, *Lymnaea stagnalis* and *Planorbarius corneus*. The use of the 'lung' as an air store for respiratory purposes during submergence has been at least partially supplanted by other functions. Some snails undoubtedly bring the gas-bubble in the cavity into contact with the water during submergence, and can extract sufficient oxygen by diffusional processes to prolong the period of submergence. But other animals, even of the same species, do not do this, and in such cases (perhaps in all) the hydrostatic function of the gas-filled cavity may dominate in determining the behaviour of the animal. In these larger species, the time taken for the bubble to be used up (by the extraction of oxygen to the point where the snail loses its buoyancy) is of the same order as the normal duration of a dive, suggesting that loss of buoyancy may determine the frequency of surfacing. Further, the loss of buoyancy caused by pressure at depth, and the fact that the snails are not found with gas in their cavities at just those depths where they lose their buoyancy, seems to indicate that the hydrostatic can be more important than the respiratory function in some species.

C. M. Yonge

[1] Yonge, C. M., *Phil. Trans. Roy. Soc.*, B, **232**, 443 (1947).
[2] Yonge, C. M., *Trans. Roy. Soc. Edin.*, B, **62**, 443 (1953).
[3] Yonge, C. M., *Phil. Trans. Roy. Soc.*, B, **230**, 79 (1939).
[4] Yonge, C. M., *Pubbl. Staz. Zool. Napoli*, **29**, 151 (1957).
[5] Yonge, C. M., *Phil. Trans. Roy. Soc.*, B, **237**, 335 (1953).
[6] Owen, G., *Quart. J. Micro. Sci.*, **94**, 57 (1953).
[7] Yonge, C. M., *Univ. Calif. Publ. Zool.*, **55**, 421 (1952).
[8] Owen, G., *Phil. Trans. Roy. Soc.*, B (in the press).
[9] Owen, G., Trueman, E. R., and Yonge, C. M., *Nature*, **171**, 73 (1953).
[10] Beedham, G. E., *Nature*, **174**, 750 (1954); *Quart. J. Micr. Sci.*, **99**, 181 (1958); *Quart. J. Micr. Sci.* (in the press).
[11] Hunter, W. Russell, *Proc. Roy. Soc. Edin.*, B, **65**, 84 (1953).
[12] Hunter, W. Russell, *Proc. Roy. Soc. Edin.*, B, **65**, 143 (1953).
[13] Hunter, W. Russell, *Glasg. Univ. Publ., Stud. Loch Lomond*, **1**, 58 (1957).

TIME-SPAN OF DISCRETION IN JOB ANALYSIS

A BOOK by Dr. Elliott Jaques* described a new approach to problems of payment for work involving, among other things, a new way of analysing the work content of roles and a suggested means of measuring responsibility. For the past eighteen months, J. M. M. Hill has been engaged in examining some of the concepts put forward in this book, in testing their validity, and in recommending if and how they should be used for the solution of problems experienced by the Glacier Metal Company, of which he is the policy research officer. In a recent paper† he describes some of the preliminary results of his examination.

The kernel of Jaques's approach may be described as follows. The work activities (or duties) which, under normal conditions of industrial contract employment, a man performs in return for pay may be divided into those that are prescribed (laid down for him so that he has no authorized choice in the matter) and those that are discretionary (in that judgment or the making of choices is called for from him). All jobs—even the most apparently 'routine'—call for some exercise in discretion, and no discretion is allowed to continue indefinitely without being subject to review by a superior. Jobs differ in the maximum length of time that discretion will be allowed to continue before a review takes place, and this maximum length of time—the time-span of discretion—is of fundamental theoretical and practical importance.

* "Measurement of Responsibility" (Tavistock Publications, Ltd., 1956).

† Tavistock Pamphlets No. 1: The Time-Span of Discretion in Job Analysis. By J. M. M. Hill. Pp. 29. (Reprinted from *Human Relations*, Vol. 9, No. 3.) (London: Tavistock Publications, Ltd., 1958.) 3s. 6d. net.

The time-span of discretion is a measure of level of work and of responsibility. That time-span of discretion is related to salary, inasmuch as there exists an ascending scale of monetary salaries corresponding to ascending time-spans of discretion. An individual doing a job in industry may be receiving remuneration at, above or below the level appropriate to the time-span of discretion of the job in question. Each of these three possibilities will be associated with different characteristics as regards the satisfaction and behaviour of those concerned. In particular, payment at the appropriate level will be experienced by the individual as satisfactory—he will not actively press for increase and will not express disruptive disaffection.

If Dr. Jaques's hypothesis is correct, it is a matter of fundamental importance to industry and may even provide a basis on which the apparently intractable problems of differentials may be settled. Before such notions and other economic implications of the idea may be investigated, Dr. Jaques's findings must be checked by observation and experiment and the actual time-span of discretion of jobs must be determined.

In the course of his work, Mr. Hill has been concerned with assessing the time-span of jobs and with the communication of the means of such assessment. In his paper the dependence of the existence of a clear time-span of discretion of a job on the existence of a clearly structured work situation is described, and some of the implications of this examined. Problems of assessing time-span in situations of unclarity are also discussed. The meaning of the term discretion is then described, expanded and exemplified, and reference made to some of the difficulties that may be met in discovering the discretionary aspects of a job. A review mechanism is then defined as any systematic means by which a manager becomes aware of the quality of his subordinates' use of discretion, and this definition is expanded and exemplified. Three kinds of review mechanisms discovered are described as:

Direct review, in which a subordinate hands back a completed piece of work to his manager for full inspection.

Indirect positive review, in which a manager deliberately seeks information about the way in which his subordinate has been using discretion, from sources outside that subordinate's control.

Indirect negative review, in which a manager relies on the fact that he will hear of the matter should his subordinate use discretion inadequately.

Jobs are then grouped as 'single aspect' or 'multiple aspect' according to whether only one or many different kinds of work activities are carried out. The boundaries between the different aspects of a multiple-aspect job are termed either 'permeable' or 'impermeable' according to the extent to which a review of discretion in one aspect leads to review of other aspects.

Within the framework given, a job may be set up in reality with a range of possible time-spans of discretion, and that within discoverable limits managers have choice concerning the time-span of discretion that they will allow a subordinate.

A description is also given of the means by which information about jobs may be elicited in order that the time-span of discretion may be assessed. Three examples of time-span analysis are presented and discussed. In each case the analysis concerns a particular kind of work, namely—the work of a draughtsman, a manual operator's work, and research work.

In future papers it is hoped to present an analysis of line management jobs, to examine the relationship of time-span with salary, to describe the use of the time-span instrument for organizational design, and to examine the implications that the use of such an instrument has for personnel management and for work study in industry.

EVIDENCE FOR PERMEABILITY MINIMA IN LOW-PRESSURE GAS FLOW THROUGH POROUS MEDIA

By Dr. D. M. GROVE and M. G. FORD

Queen Mary College, University of London, Mile End Road, London, E.1

FOR a gas flowing in a porous medium at a pressure such that λ, the mean free path of the gas molecules, is much less than $2r$, the mean pore diameter, it is well established[1] that there is a linear relationship between K, the permeability (cm.²/sec.), and $\bar{p}$, the mean pressure of the gas in the porous medium. Among the various equations put forward to represent such flow is that developed from the Kozeny equation by Carman and Arnell[2,3], which may be written as:

$$K = \frac{\varepsilon^3 \bar{p}}{k\eta A^2} + \frac{8}{3}\frac{\delta\varepsilon^3}{k'A}\sqrt{\frac{2RT}{\pi M}} \qquad (1)$$

where ε = porosity (cm.³/cm.³) of the porous medium; A = specific surface area (cm.²/cm.³) of the porous medium; k = Kozeny constant (5·0); k' = shape factor (2·0 to 2·5 for most porous media); η = viscosity of the gas; M = molecular weight of the gas; and δ = a coefficient of the order of unity.

All equations for slip flow are of the form[4]:

$$K = K_p\bar{p} + \delta K_k \qquad (2)$$

where K_p is the Poiseuille (viscous) flow and K_k is the contribution due to slip of the gas molecules at the pore walls[5]. The slip term is of the same form as the expression for Knudsen (molecular) flow, which for a porous medium may be written as[6]:

$$K_k = \frac{8}{3}\frac{\varepsilon^3}{A}\sqrt{\frac{2RT}{\pi M}} \qquad (3)$$

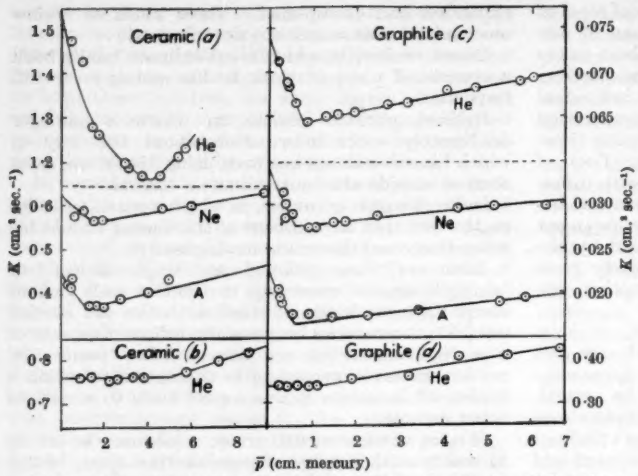


Fig. 1. Flow of inert gases at 25° C. through porous ceramics and through graphites

where the mean hydraulic radius $m = r/2$ is replaced by ε/A, assuming that the porous medium consists of uniform capillaries. An additional factor ε is introduced because flow occurs only in the pores and not through the entire cross-section.

At low pressures, when $\lambda \gg 2r$, viscous flow gives place to molecular streaming, the permeability K becomes independent of the mean pressure $\bar{p}$, in accordance with equation (3). A flattening of the permeability curve at low pressures has been observed by several workers[7,8]. Conversely, for materials having extremely fine pores, there may be no measurable Poiseuille contribution even at pressures of half an atmosphere[9,10]. Considerable discussion[11] has taken place concerning the numerical constants of K_p and K_b, including the shape factors k and k', and various values have been given to the coefficient δ, which appears to alter both with the mean pressure of the gas and with the material of the capillaries.

Gas flow in a single capillary also gives a linear relationship between K and $\bar{p}$ in the region of slip flow, but instead of the flattening at low pressures, a minimum is observed[12–14] in the permeability curve. More recently, Huggill[15] has obtained indications of such a minimum using a block of 1,400 capillaries of polymerized methyl methacrylate. Only a few tentative claims[16,17] have been made for permeability minima in porous media. Pollard and Present[18] have shown theoretically that a minimum is not, in fact, to be expected, since mean free paths much greater than the pore diameter will not occur in the tortuous and irregular capillaries of a porous medium.

Using consolidated porous media, we have now obtained several examples of quite marked permeability minima, some of which are shown in Fig. 1. The curves (*a*) for the inert gases flowing through a porous ceramic were the first we obtained of this type; the curves (*c*) for a relatively impermeable graphite are examples of the higher degree of accuracy obtained more recently. The existence of a minimum cannot be solely a property of the material of the porous medium, since (*b*) and (*d*), which are curves for other grades of ceramic and graphite, respectively, show a flattening at low pressures instead of a minimum. Nor does the minimum depend in a simple way on the mean pore radius calculated from the slope of the linear portion of the permeability curve. Table 1 gives the porosity ε determined by density measurements or helium displacement. This has then been used to calculate the mean pore radius, $r = 2\varepsilon/A$, and the specific surface area A from the first term in equation (1).

The results suggest that pore size distribution, rather than the mean pore radius, may be the factor which determines whether or not a minimum is observed.

Preliminary measurements of the surface areas of the ceramic and graphite samples by the standard Brunauer–Emmett–Teller method give in each case results between five and seven times greater than the values of A shown above. It is to be expected that permeability measurements will give a lower result since gas flow will occur mainly through the large pores and any blind pores will not take part, whereas the small pores, whether blind or not, will make a relatively greater contribution to the Brunauer–Emmett–Teller surface area[9].

Table 1

Porous medium	ε (cm.³/cm.³)	$r \times 10^4$ (cm.)	A (cm.²/cm.³)
Ceramic (*a*)	0·442	0·91	9,760
Ceramic (*b*)	0·280	1·30	4,320
Graphite (*c*)	0·183	0·348	10,520
Graphite (*d*)	0·174	1·61	2,160

The mean pressure corresponding to the minimum varies with the gas used, but for each sample the mean free path of the gas molecules is approximately constant at that pressure. For the ceramic (*a*) it is about seven times the mean pore radius, and this agrees with the results of Knudsen[12] and others for a single capillary, for which the ratio λ/r at the minimum is about 10. For the graphite (*c*), however, the ratio is 50. It is interesting to note that both for ceramic (*b*) and graphite (*d*) the end of the flat portion of the permeability curve corresponds closely to the position of the minimum for other grades of the same material, although the pore radii of the two graphite samples differ so widely.

This work will be published and discussed in more detail elsewhere.

[1] Carman, P. C., "Flow of Gases through Porous Media", Chap. 3 (Butterworth, 1956).
[2] Carman, P. C., *Trans. Inst. Chem. Eng. London*, **15**, 150 (1937).
[3] Carman, P. C., and Arnell, J. C., *Canad. J. Res.*, A, **26**, 128 (1948).
[4] Adzumi, H., *Bull. Chem. Soc. Japan*, **12**, 304 (1937).
[5] Millikan, R. A., *Phys. Rev.*, **21**, 217 (1923).
[6] Holmes, W. R., *Nature*, **157**, 694 (1946).
[7] Arnell, J. C., and Henneberry, G. O., *Canad. J. Res.*, A, **26**, 29 (1948).
[8] Barrer, R. M., and Grove, D. M., *Trans. Farad. Soc.*, **47**, 826 (1951).
[9] Barrer, R. M., and Barrie, R. A., *Proc. Roy. Soc.*, A, **213**, 250 (1952).
[10] Barrer, R. M., and Strachan, E., *Proc. Roy. Soc.*, A, **231**, 52 (1955).
[11] Carman, P. C., *Proc. Roy. Soc.*, A, **203**, 55 (1950).
[12] Knudsen, M., *Ann. Physik.*, **28**, 75 (1909).
[13] Adzumi, H., *Bull. Chem. Soc. Japan*, **12**, 292 (1937).
[14] Klose, W., *Ann. Physik.* (5), **11**, 73 (1931).
[15] Huggill, J. A. W., *Proc. Roy. Soc.*, A, **212**, 123 (1952).
[16] Flood, E. A., Tomlinson, R. H., and Leger, A. E., *Canad. J. Chem.*, **30**, 348 (1952).
[17] Munro, A. G., and Gaffee, D. I., *Nature*, **178**, 197 (1956).
[18] Pollard, W. G., and Present, R. D., *Phys. Rev.*, **73**, 762 (1948).

CONDENSATION PRODUCED BY ULTRA-VIOLET LIGHT

By Dr. A. J. BARNARD and W. L. MOUTON
Physics Department, University of Natal, Pietermaritzburg, South Africa

IT was discovered by Lenard and Wolff[1] that the exposure of a damp gas in a cloud chamber to ultra-violet light may result in a marked increase in the condensation on expansion. Their experiments indicate that the ultra-violet light (although of too long wave-length to cause ionization) may form some kind of uncharged condensation nuclei. C. T. R. Wilson[2] investigated the effect in air saturated with water vapour, and ascribed it to the formation of hydrogen peroxide. He reported, however, that an increase in condensation could also be observed when the air was replaced by carbon dioxide or by hydrogen. More recently, Crane and Halpern[3] observed the effect in a conventional cloud chamber with an air – ethyl alcohol filling, and they attributed it to the formation of atomic oxygen. This theory was supported by Farley[4], who investigated the condensation of water vapour in a rubber-diaphragm cloud chamber. McHenry and Twomey[5], on the other hand, attributed the increased condensation observed with water vapour to the presence of an ammonia contamination in the air. It is evident that there still exists considerable doubt as to which component of the gas – vapour mixture is responsible for the effect. The present investigation was therefore undertaken with the object of ascertaining the origin of the condensation nuclei.

The initial experiments were performed with various gas – vapour mixtures in a conventional rubber-diaphragm cloud chamber. Light from a mercury discharge lamp equipped with a quartz lens was brought to a focus inside the chamber through a quartz window. At an expansion ratio normally just sufficient for the onset of spontaneous condensation, prior exposure to ultra-violet light produced a dense cloud. In these and in the subsequent experiments every fast expansion was always followed by a series of slow expansions to clear the chamber. The effect was studied using water as condensant and the following permanent gases in turn: room air; cylinder oxygen, nitrogen and argon; and, finally, cylinder nitrogen and argon which had been passed over heated copper to remove residual oxygen. No significant differences in the condensation could be seen with the different gases; such differences as were observed could always be explained in terms of the different rates of diffusion of the nuclei through the gases and/or the different ratios of the specific heats of the gases. It was noticed, however, that for a particular filling the density of the cloud due to ultra-violet irradiation increased markedly with time, attaining an equilibrium value after a few days. A similar effect was noticed when using ethyl alcohol as condensant. These experiments indicate that the nuclei do not arise from the permanent gas, but from a contamination given off by the chamber materials (probably by the rubber diaphragm).

To check this conclusion the chamber illustrated in Fig. 1 was constructed, and operated with water

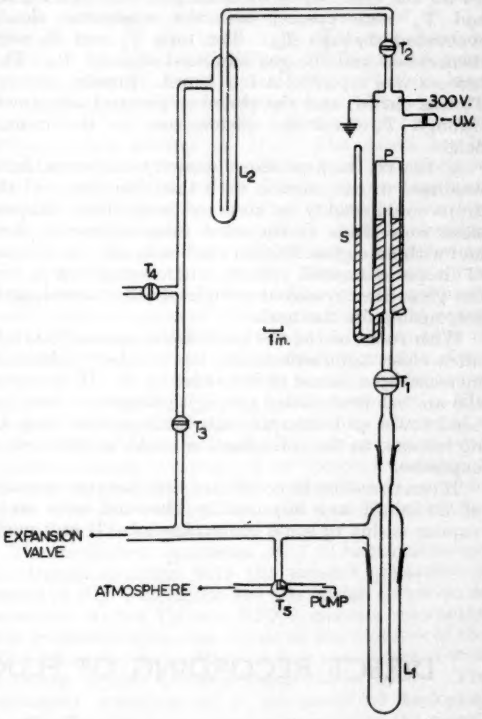


Fig. 1

as condensant. In this chamber only glass, quartz, water and tap grease ('Apiezon *L*') came in direct contact with the working volume. (The tap T_2 could not be eliminated since preliminary experiments revealed that in sealing off a 'Pyrex' tube numerous nuclei are produced on irradiation.) All gases admitted to the chamber, either during the filling process or the operation of the chamber, first passed through the traps L_1 or L_2 surrounded by liquid air (or solid carbon dioxide). Ultra-violet light was admitted through the quartz tube Q fused to the chamber via a graded seal. To make an expansion, the space underneath the piston P was suddenly connected to a partially evacuated vessel through a magnetically controlled valve (the tap T_1 being open). The expansion ratio was controlled by adjusting the pressure in the partially evacuated vessel.

Before using the chamber, the tube above T_2 was broken, the chamber removed and washed out with a 1 : 1 mixture of concentrated sulphuric and concentrated nitric acid. Steam generated in an all-glass apparatus was then passed through the chamber for

15 hr. The distilled water used as condensant was prepared by the method recommended by Faure *et al.*[6]. De-ionized water was distilled from a mixture of potassium permanganate and sodium hydroxide and then directly into the chamber from phosphoric acid. A tin condenser was used in the final stage to avoid the impurities dissolved by water when condensing on glass. After filling, the taps T_1 and T_2 were closed, the chamber replaced and the tube above T_2 again sealed to the rest of the apparatus. To fill the chamber with clean gas, the taps T_1, T_2 and T_3 were opened and the apparatus slowly evacuated through T_5. The taps T_1 and T_5 were then closed and the gas admitted through T_4. This process was repeated a few times. Finally, the tap T_1 was closed, and the chamber pumped out slowly through T_2 until the piston rose to the desired height.

A 125-W. high-pressure mercury-discharge lamp was used in conjunction with this chamber, and the drops could readily be observed in its light. Expansions were made at the same ratio alternately with and without a glass filter in the beam, and the number of drops estimated visually. (It was checked that the glass filter removed completely the wave-lengths responsible for the nuclei.)

With room air as the permanent gas, exposure to ultra-violet light still caused the number of drops to increase by a factor of the order of 10. If, however, the air was first passed through phosphoric acid in a bead tower and then through the liquid air trap L_2, no increase in the condensation could be detected on exposure.

It can therefore be concluded that the vast majority of nuclei (if not all) usually observed with water vapour is due to some contamination. If any nuclei are formed with distilled water and purified air, the number is too small to be detected with our technique. So far as we can see, no particular care had been taken by previous workers to eliminate impurities, and these impurities could have given rise to the observed effects.

Wilson[2] also found that a cloud could be formed by merely irradiating damp air with an intense ultra-violet beam. His experiment was repeated using a glass vessel with a quartz tube fused to it via a graded seal. With distilled water and room air in the apparatus, no cloud could be seen even after irradiating for about 10 hr. When traces of impurities (such as carbon tetrachloride or ammonia) were introduced, however, a cloud formed after exposing for a few seconds. With pure carbon tetrachloride (fractionally distilled from a 10-ft. column containing stainless steel rings) a cloud of small drops could also be formed by irradiation only.

No explanation of the mechanism of the condensation process is attempted at this stage. Further investigation is necessary, and the work is being continued.

This investigation was started by one of us (A. J. B.) at the Department of Natural Philosophy, University of Glasgow. We wish to thank Prof. P. I. Dee and Mr. J. R. Atkinson for their interest and for helpful discussions.

[1] Lenard, P., and Wolff, O., *Wied. Ann.*, **37**, 443 (1889).
[2] Wilson, C. T. R., *Phil. Trans. Roy. Soc.*, A, **192**, 403 (1899).
[3] Crane, H. R., and Halpern, J., *Phys. Rev.*, **56**, 232 (1939).
[4] Farley, F. J. M., *Proc. Roy. Soc.*, A, **207**, 527 (1951).
[5] McHenry, J. J., and Twomey, S., *Proc. Roy. Irish Acad.*, A, **55**, 51 (1952).
[6] Faure, A., Faure, P. K., and Gledhill, J. A., *J. S. Afric. Chem. Inst.*, **4**, 19 (1951).

DIRECT RECORDING OF FLUORESCENCE EXCITATION SPECTRA

By Dr. C. A. PARKER

Admiralty Materials Laboratory, Holton Heath, Poole, Dorset

THE use of absorption spectroscopy for the identification of unknown substances is limited to concentrations of 10^{-5} *M* or more, the measurement of a complete absorption spectrum at lower concentrations than this requiring an inconveniently long optical path. The measurement of fluorescence emission spectra as a means of identification at much lower concentrations is now becoming commonplace, but unfortunately the fluorescence emission spectrum alone is, in general, not so specific as the absorption spectrum because it corresponds to transitions only from the lowest excited state of the molecule, irrespective of the wave-length used for excitation. Previous work in this laboratory[1] has shown that the measurement of the fluorescence excitation spectrum provides a method of identification which is as specific as the absorption spectrum and can be made at far lower concentrations. It was suggested[1] that the 'true' fluorescence excitation spectrum should be defined as the fluorescence output (of a sufficiently dilute solution) measured as a function of the frequency of the exciting light at constant quantum intensity. Under these conditions the fluorescence output is proportional to the product of the fluorescence quantum yield, φ, and the extinction coefficient, ε, of the fluorescent substance, and for many substances where φ is independent of frequency, the excitation spectrum is identical with the absorption spectrum. It has the advantage over the absorption spectrum that it can be measured in the presence of other strongly absorbing substances provided that sufficiently dilute solutions are used. Weber and Teale[2] have recently also discussed these points. They have investigated the fluorescence excitation spectra of a variety of organic compounds in solution and report a list of twenty-six compounds for which the fluorescence quantum yield is constant over a wide range of wave-lengths. They have also described conditions under which the fluorescence yield may not be constant, and the useful conclusions which can be drawn from a comparison of the excitation and absorption spectrum of a pure substance.

It is unfortunate that most spectrofluorimeters record only the apparent excitation spectrum, that

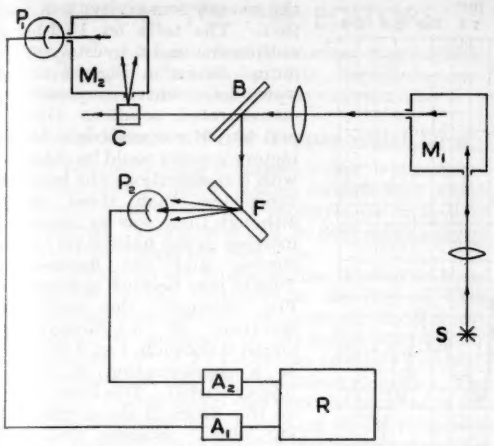


Fig. 1. Arrangement for recording true excitation spectra

is, the product $I\varphi\varepsilon$ versus frequency or wave-length, and since the intensity (I) available at the exit slit of the monochromator used to isolate the exciting light often varies considerably with frequency, the spectrum observed is seriously distorted and important features may be missed entirely. The true excitation spectrum can, of course, be calculated from the observed spectrum by measuring the spectral intensity of the light reaching the fluorimeter cell, but this calculation is time-consuming, particularly when a large number of experiments have to be made.

The value of the method in analytical chemistry would obviously be greatly increased if the true excitation spectrum (or a close approximation to it) could be directly recorded by the spectrofluorimeter. The arrangement shown in Fig. 1 has been designed for this purpose. The exciting light from the monochromator M_1 is focused on the sample in cell C, but a small proportion of the beam is reflected by the clear silica plate B on to the front surface of the fluorescent screen F. This consists of a silica cell, 5 mm. optical depth, containing a suitable fluorescent solution the fluorescence of which is viewed through the back face of the cell by the monitoring photomultiplier P_2. A suitable band of fluorescent light from the sample in C is selected by the monochromator M_2 and is received by the photomultiplier P_1. After amplification the outputs of P_1 and P_2 are passed to the ratio recorder R. The frequency drum on M_1 is motor driven, and as the frequency is varied the slits are adjusted so as to maintain the output of P_2 approximately constant (within a factor of 2). If the contents of F are suitably chosen, the output of P_2 can be made proportional to the quantum output of M_1 over a wide frequency-range. R then records the true fluorescence excitation spectrum of the sample in C.

Fluorescent solutions chosen for the monitoring cell F should ideally have constant fluorescence yield and absorb substantially the whole of the beam within a depth of about 1 mm. or less, over the whole spectrum-range concerned. Thus the fluorescent light has to penetrate a further 4 mm. of solution before reaching P_2 and this solution thus acts as a filter for the exciting light and at the same time ensures that substantially the same band of fluorescent light reaches P_2, irrespective of the depth of penetration of the incident beam[3]. In preliminary experiments a solution of $4{\cdot}4 \times 10^{-3}$ M fluorescein in a mixture of sodium carbonate and bicarbonate (both 0·1 N) was used. Although the fluorescence yield of this solution is not precisely constant[4] it was sufficiently so for these preliminary trials. The apparent relative fluorescence yield of this solution was determined by measuring the dose-rates of monochromatic ultra-violet light received by the contents of the cell, C, using the ferrioxalate actinometer[5] and comparing these with the corresponding readings of P_2. A Siemens xenon arc lamp type XC was used as a source of light with Hilger $D247$ quartz prism monochromators for M_1 and M_2. Rather large fluctuations in light intensity were observed, and a number of experiments were done at each wave-number setting of M_1. The mean results for the apparent relative efficiency of the monitoring screen (column 5 of Table 1) are accurate to about $\pm$ 5 per cent. They represent the correction which must be applied to the observed output of P_2 to obtain the relative intensity received by the contents of C. (They do not represent precisely the true relative fluorescence quantum yield of the contents of F owing to changes of reflectivity of the beam-splitter B and the transmission of the cells F and C.) The overall deviation from linearity is $\pm$ 10 per cent. This is adequate for many purposes without applying the correction. The linearity can no doubt be improved by choice of a more suitable solution for F. The range (which with fluorescein extends to below $2{\cdot}0\mu^{-1}$ before transmission becomes appreciable) can be extended to somewhat lower wave-numbers by the use of a solution of rhodamine B in ethylene glycol[6].

The excitation spectrum of 1 : 2-benzanthracene in ethanol recorded with the present apparatus is shown in Fig. 2 alongside the absorption spectrum as measured with a Unicam $SP500$ spectrophotometer. The excitation spectrum shows all the features of the absorption spectrum although it is not identical with it owing to the differing band-widths used. The excitation spectrum of a substance of biological interest, 5-hydroxytryptamine (present as the creatinine sulphate complex), is shown in Fig. 3 (curve 1). The fluorescence of this substance occurs entirely in the ultra-violet region (maximum at $2{\cdot}9\mu^{-1}$). The excitation spectrum is similar to the absorption spectrum and is clearly a much more useful record than the second curve which was recorded at constant slit width without the use of the fluorescent screen

Table 1. Apparent Relative Fluorescence Efficiency of Monitoring Screen
($4{\cdot}4 \times 10^{-3}$ M fluorescein in a mixture of sodium carbonate and bicarbonate, both 0·1 N).

Monochromator setting (μ^{-1})	Half-band width of slit setting (μ^{-1})	Light intensity on fluorimeter cuvette (einsteins/min. $\times 10^6$)	Monitor reading (arbitrary units)	Apparent relative efficiency of monitor
2·2	0·016	0·90	1·08	1·20
2·4	0·025	2·05	2·18	1·06
2·6	0·023	1·17	1·29	1·10
2·8	0·020	0·77	0·77	1·00
3·0	0·037	1·88	2·05	1·09
3·2	0·034	1·35	1·40	1·04
3·4	0·046	1·47	1·55	1·05
3·6	0·057	1·46	1·49	1·02
3·8	0·065	1·08	1·15	1·06
4·0	0·085	1·06	1·15	1·08
4·3	0·078	0·234	0·257	1·10

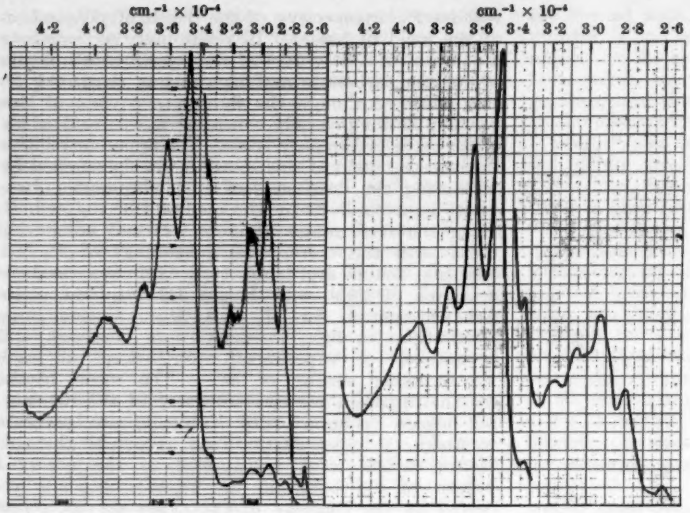


Fig. 2. 1 : 2-Benzanthracene in ethanol. Left, excitation spectrum with fluorescence observed at 2·25–2·45μ^{-1}; right, absorption spectrum

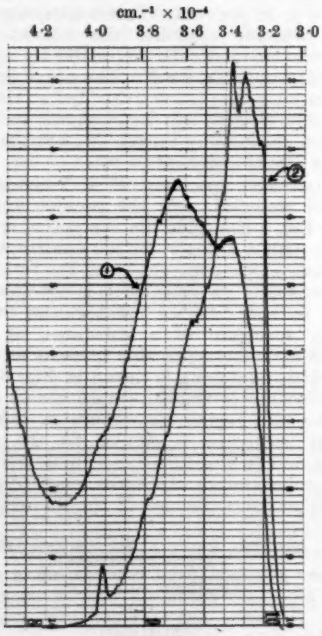


Fig. 3. 5-Hydroxytryptamine creatinine sulphate in water. Excitation spectrum recorded with (curve 1) and without (curve 2) the monitor. Fluorescence observed at 2·85–3·0μ^{-1}

monitor. Owing to the rapid change in the intensity of the exciting light with frequency the latter bears little resemblance to the absorption spectrum of the compound.

The present measurements were made using a monochromator for the isolation of both the exciting and fluorescent light. Owing to the comparatively narrow aperture of the monochromators, the intensity of the fluorescent light available at P_1, and hence also the overall sensitivity, was limited. The tests on 1 : 2-benzanthracene and 5-hydroxytryptamine shown in Figs. 2 and 3 were done with comparatively concentrated solutions (10^{-6} M and 10^{-5} M respectively). Satisfactory spectra could be obtained with concentrations one hundred times less than these values although there was an inevitable increase in the noise-level on the curves, and the fluorescence 'blank' also became appreciable. For example, the excitation spectrum of 5-hydroxytryptamine is shown in Fig. 4 recorded at a concentration of 10^{-7} M (upper curve). The lower curve on this figure is the corresponding 'blank' obtained with pure water in the cell. Instrumental sensitivity can be increased considerably by the use of filters to isolate the fluorescence for P_1, but at the expense of some versatility and convenience. (The choice of secondary filters is sometimes very difficult with substances fluorescing in the ultra-violet region.) When working at very low concentration great care must be taken to avoid interference by fluorescence or scatter from solvent and by fluorescence of cell or secondary filters. It is, of course, always necessary to take measurements with pure solvent in the cell to determine the magnitude of the 'blank' excitation curve.

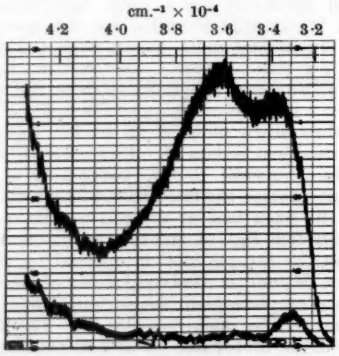


Fig. 4. Excitation spectrum at high sensitivity. Upper curve, 10^{-7} M 5-hydroxytryptamine creatinine sulphate in water; lower curve, water alone

I thank Dr. E. J. Bowen for much helpful discussion. I also wish to acknowledge the assistance rendered by Mr. C. G. Hatchard, who carried out the chemical actinometry.

[1] Parker, C. A., and Barnes, W. J., *Analyst*, **82**, 606 (1957).
[2] Weber, G., and Teale, F. W. J., *Trans. Farad. Soc.*, **54**, 640 (1958).
[3] Bowen, E. J., *Proc. Roy. Soc.*, A, **154**, 349 (1936).
[4] Lavorel, J., *J. Phys. Chem.*, **61**, 1600 (1957).
[5] Parker, C. A., *Proc. Roy. Soc.*, A, **220**, 104 (1953). Hatchard, C. G., and Parker, C. A., *Proc. Roy. Soc.*, A, **235**, 518 (1956).
[6] Melhuish, W. H., *N.Z. J. Sci. and Tech.*, B, **37**, 142 (1955). Weber, G., and Teale, F. W. J., *Trans. Farad. Soc.*, **53**, 646 (1957).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

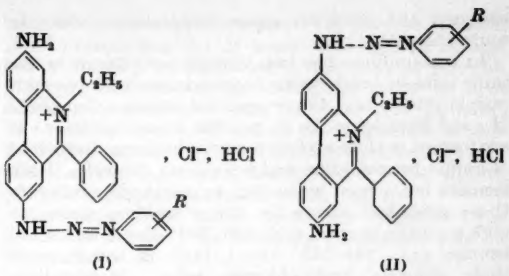
Metamidium: a New Trypanocidal Drug

THIS communication describes a new trypanocide, which has been found to possess considerable potentiality as a curative and as a prophylactic drug, both in laboratory experiments and in field trials carried out in Africa during the past year.

In following up the long-standing interest in these laboratories in the trypanocidal activity of both phenanthridinium salts[1] and the aromatic diamidines[2], we decided to prepare the *p*-amidinophenyldiazoamino-derivative[3] of 2 : 7-diamino-10-ethyl-9-phenylphenanthridinium chloride (homidium chloride). The diazoamino linking group was selected because of the structural relationship our product would then bear to the recently introduced curative trypanocidal drug 'Berenil', *p*-amidinophenyldiazoamino-*p*-benzamidine[4].

The coupling reaction between diazotized *p*-aminobenzamidine (1 mol.) and homidium chloride in the presence of sodium acetate (7 mol.) at a temperature of 0–5° C. yields a mixture of two isomeric *p*-amidinophenyldiazoamino-derivatives, which can be separated by precipitation from water with sodium chloride, followed by fractional crystallizations from water and from methanol. The relatively water-insoluble isomer, m.p. 287–289° (dec.), was purple and the other, m.p. 236–240° (dec.), red. Both isomers were self-indicating on paper electrophoresis in 3 *N* acetic acid, the purple isomer being distinctly more mobile than the red; this provided an invaluable means of following the progress of separation procedures.

Since in 2 : 7-diamino-10-methyl-9-phenylphenanthridinium chloride (dimidium chloride) it is the



7-amino-group which reacts preferentially on acetylation[5], we provisionally assigned the structure (I; R = *p*-amidino) to the predominating purple isomer and (II; R = *p*-amidino) to the red isomer. Work to provide unambiguous proof of structure continues. A diazoamino structure was expected from the method of preparation and the expected microanalytical figures were obtained for both isomers. Infra-red spectra ruled out the remote possibility that the isomers were due to the existence of two stable tautomeric forms of the diazoamino-group in one or other of the structures (I) or (II). The presence of a diazoamino-group in each isomer was confirmed by the rapid evolution of nitrogen on boiling in 6 *N* sulphuric acid—the red isomer yielded nearly the theoretical volume of nitrogen, while the purple regularly yielded only about 65 per cent (the reason for this deficiency is at present unexplained).

The very promising results obtained on testing the isomers (I and II; R = *p*-amidino) as trypanocides led us to study extensively structure/activity relationships among similar pairs of isomers, particularly those in which the substituent R and the group in the phenanthridine-10 position were varied. As a result, we found that the most promising product was a mixture of the two isomers (I and II; R = *m*-amidino)[6], first designated M & B 4404, and later

Table 1. TOXICITY AND THERAPEUTIC ACITIVITY AGAINST *T. congolense* IN MICE

Compound having structure I or II	Substituent R in structures I or II	*LD*50 (mgm./gm.) subcutaneous	*CD*50 (mgm./gm.) subcutaneous		
			Strain of *T. congolense*		
			Laboratory (*a*)	Kenya (*b*)	Sakwa XXIV (*c*)
Purple isomer	*p*-amidino	1·0	0·002		
Red isomer	,,	0·30	0·00075		
Purple isomer	*m*-amidino	0·43	0·00003		
Red isomer	,,	0·26	0·000002		
Compound					
Metamidium chloride hydrochloride		0·23	0·000008	0·003	0·00004
Metamidium suramin salt		>5·0	0·000027		
Homidium chloride		0·07	0·00003	Not curative at 0·01	0·0015

(*a*) Isolated in Tanganyika in 1933. (*b*) Isolated in Kenya in June 1956. (*c*) Isolated at Sakwa (Kenya) in December 1956.

Table 2. PROPHYLACTIC ACTIVITY AGAINST THE LABORATORY STRAIN OF *T. congolense*

Compound having structure I or II (R = *m*-amidino)	Dose (mgm./gm.) subcutaneous	Number of mice protected out of number challenged								
		2	3	4	8	9	12	16	20	26
		(weeks after dosing)								
Purple isomer	0·025		5/17	1/8	0/11					
Red isomer	0·025		11/11		6/6		8/8	5/7		
Compound										
Metamidium chloride hydrochloride	0·025			12/12	12/12		6/6	10/11	6/10	0/5
	0·005			4/4	6/6	5/6				
	0·001	6/6		5/6		0/3				
Homidium chloride	0·025	1/10								
Berenil	0·06	0/10								

assigned the common name metamidium chloride hydrochloride.

In metamidium the two isomers are present in the same relative proportions (approximately 55 per cent purple isomer and 45 per cent red isomer; Campbell, H., and Muggleton, D. F., private communication) as are formed in the coupling reaction between diazotized *m*-amino-benzamidine and homidium chloride. Both isomers have been separated by methods similar to those described above for the *p*-amidino series, to give a purple isomer, m.p. 258–260° (dec.), and a red isomer, m.p. 244–245° (dec.), both in the form of their chloride hydrochloride salts. Metamidium chloride hydrochloride is 12·5 per cent w/v soluble in water at 25°, the *p*H of a 1 per cent solution being 6·65.

The suramin salt[7] of metamidium, designated M & B 4427, was precipitated and dried *in vacuo* at room temperature to give a dark purple powder, which was less than 20 μgm./ml. soluble in water at 20° C. For biological evaluation this solid was presented as a 10 per cent w/v ball-milled aqueous suspension.

The foregoing compounds were examined for activity against a laboratory strain of *Trypanosoma congolense* which gave an acute infection in mice. A single subcutaneous injection was administered to mice with an infection in the peripheral bloodstream of from 1–10 trypanosomes per high-power field. Ten mice were used for each dose, and five untreated controls which died within 5–7 days were included in each experiment. Homidium chloride was used as a standard.

Wet blood smears were examined three times a week for four weeks, and the number of animals clear of trypanosomes for that period (that is, cured) was noted for each dose. The *CD*50 (the dose which cured 50 per cent of the mice) was then obtained graphically for each compound using de Beer's method[8]. The subcutaneous *LD*50 for each compound was also obtained in mice.

The results of these therapeutic and toxicity experiments are given in Table 1, together with the results obtained with metamidium and homidium against two more recently isolated strains of *T. congolense*, which we obtained through the courtesy of the East Africa Trypanosomiasis Research Organization, Tororo, and the Veterinary Research Laboratory, Kabete. These experiments were carried out less than twelve months after the strains were isolated.

These results show that metamidium chloride hydrochloride was more active than homidium chloride against all three strains of *T. congolense*.

Prophylactic experiments in mice were also carried out with some of the compounds. In these experiments a single subcutaneous injection of the substance was given to a large batch of mice and groups of them were challenged intraperitoneally with approximately 65,000 *T. congolense* (laboratory strain) per mouse at various times after dosing. No mouse was challenged more than once.

The mice were examined for trypanosomes for four weeks after challenge, as in the therapeutic experiments, and those which remained clear of trypanosomes for this period were considered to have been protected. Untreated controls were infected at each challenge and these became positive for trypanosomes within five days.

The results of these experiments are given in Table 2.

Metamidium chloride hydrochloride completely protected mice for up to sixteen weeks at about one-ninth of the *LD*50. This was an interesting result because neither the parent compound, homidium chloride, nor the drug 'Berenil', with which metamidium shares some structural similarities, has any appreciable prophylactic activity at one-third of the *LD*50.

Of the two isomers of metamidium, the red was more active than the purple both therapeutically and prophylactically, but there was little difference in their toxicities.

We thank Dr. H. J. Barber and Dr. R. Wien for the constructive interest they have taken in this work.

W. R. Wragg
K. Washbourn
K. N. Brown
J. Hill

Research Laboratories,
May and Baker, Ltd.,
Dagenham, Essex.
Sept. 5.

[1] Barber, H. J., *et al.*, *J. Chem. Soc.*, 84 (1947); *J. Soc. Chem. Indust.*, 82 (1950). Libman, D. D., and Slack, R., *J. Chem. Soc.*, 2588 (1951). Davis, M., *ibid.*, 337 (1956), 828 (1958).
[2] Ashley, J. N., Barber, H. J., Ewins, A. J., Newbery, G., and Self, A. D. H., *J. Chem. Soc.*, 103 (1942); for other references see Davis, M., *ibid.*, 907 (1958).
[3] British Provisional Patent Application No. 9217/56.
[4] British Patent 728, 457/1955; Milne, A. H., Robson, J., and Lwebandiza, T., *Vet. Rec.*, **62**, 280 (1955). Jensch, H., *Arzneimittel Forsch.*, **5**, 634 (1955).
[5] British Patent 746,027, March 7, 1956. Walls, L. P., *J. Chem. Soc.*, 3514 (1950).
[6] British Provisional Patent Application No. 21814/56.
[7] cf. Williamson, J., and Desowitz, R. S., *Nature*, **177**, 1074 (1956).
[8] de Beer, E. J., *J. Pharm. Exp. Ther.*, **85**, 1 (1945).

A Rate-Governing Reaction of Protein Synthesis

Rabbit reticulocytes synthesize hæmoglobin *in vitro*. In order to maintain a high rate for at least four hours there needs to be added to the saline solution in which the cells are suspended a mixture of amino-acids, glucose, iron and an iron-chelating agent. The rate then (in four hours) is about five times that in saline alone. Glucose, iron and chelating agent have little effect on the rate unless the amino-acid mixture is added with them[1].

When in a reaction mixture complete except for one amino-acid, and that amino-acid is added in the carbon-14-labelled form and in varying concentration, the rate of its incorporation was found to vary as a first approximation with the concentration according to the equation $\frac{v}{V} = \frac{[A]}{[A] + K}$, where v is the observed rate at any given concentration, V is the maximum rate, $[A]$ is the concentration of the labelled amino-acid added to the reaction mixture and K is constant, which is formally identical with K_m in the Michaelis–Menten equation, that is to say, it is the equilibrium constant for the combination of substrate with enzyme. In the present instance $K = \frac{[B][A]}{[BA]}$, where B is a substance in the cells with which $[A]$ combines, and the rate of incorporation (fraction of the maximum) is proportional to $\frac{[BA]}{[B][BA]}$. The term $[BA]$ governs the rate of protein synthesis.

Table 1

Molar concentration of labelled leucine	Counts for 20 mgm. protein in 60 min.	Observed percentage of the maximum rate	Calculated percentage of the maximum rate for $K = 1{\cdot}25 \times 10^{-5}$
1×10^{-3}	3,369	100	100
5×10^{-4}	3,276	97	97
1×10^{-4}	1,608	47	44
5×10^{-5}	884	26	28
$2{\cdot}5 \times 10^{-5}$	598	17·7	16·6
$1{\cdot}0 \times 10^{-5}$	249	7·4	7·4
5×10^{-7}	107	3·2	2·4

Table 1 gives the results of a typical run. 0·25 ml. of packed reticulocytes was suspended in 32 ml. of a complete reaction mixture[1] except for labelled leucine, the concentration of which was varied. The temperature was 25° C., the incubation time 15 min. The proteins were washed and counted as previously described.

In different experiments the values of K varied over the range $0{\cdot}7 \times 10^{-5}$ to $1{\cdot}5 \times 10^{-5}$, but the variation within each run with concentration of leucine was according to the above equation. Preliminary experiments with labelled histidine, methionine and phenylalanine indicate that their minimum concentration for maximum incorporation was the same as that of leucine, namely, approximately 10^{-3} M, and also that their equilibrium constant was of the same order, namely, about 1×10^{-5}. The cause of the small variations from experiment to experiment needs to be understood before anything can be said regarding the value of K for different amino-acids. There may be a number of interrelated equilibrium reactions, and the value of K which is calculated would then be that for the overall equilibrium.

As there were maximum amounts of all the amino-acids needed except the labelled amino-acid the incorporation of which was measured, it follows that the hypothetical substance B, the combination of which with an amino-acid governs the rate of protein synthesis, is different for each amino-acid. These experiments do not tell what B is. Among the possibilities are that B is the locus of the amino-acid on the template or B is some specific carrier of the amino-acid.

HENRY BORSOOK

Kerckhoff Biological Laboratories,
California Institute of Technology,
Pasadena.
July 21.

[1] Borsook, H., Fischer, E. H., and Keighley, G., *J. Biol. Chem.*, **229** 1059 (1957).

Inhibition of Dextransucrase by Excess Substrate

HEHRE[1], working with the enzyme dextransucrase, showed that a plot of initial velocity v against substrate concentration deviated from linearity above a sucrose concentration of 200 mM. This was tentatively explained on the basis of a decrease in concentration of water in the stronger sucrose solutions.

Our interest in this polysaccharide-synthesizing enzyme[2] prompted us to examine this phenomenon more closely. Using fructose production as a measure of enzyme activity, the conversion of sucrose to dextran was examined in substrate concentrations ranging from 20 mM to 1,000 mM. The details of the enzyme preparation and the analytical procedure have been reported elsewhere[2]. A sucrose solution (1 ml.) containing 0·1 M acetic acid–sodium acetate buffer at pH 5·0 was added to the enzyme solution (0·2 ml.) and the mixture incubated at 30° C. in a constant-temperature water-bath for half an hour. The reaction was quenched at the conclusion of this time by the addition of 0·1 N sodium hydroxide (1 ml.) and the reducing sugars determined[3,4]. The results of these experiments are shown in Fig. 1.

Assuming that excess substrate inhibits this particular reaction, the following mechanism may be postulated[5]:

$$E + S \underset{k_2}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_3} E + P \qquad (1)$$

$$ES + S \underset{k_5}{\overset{k_4}{\rightleftharpoons}} SES \qquad (2)$$

$$K_{ss} = [ES][S]/[SES] \qquad (3)$$

where E = enzyme, P = products, S = substrate, SES = inactive complex, K_{ss} = dissociation constant for inactive complex.

The steady-state treatment of the above mechanism yields the following rate equation:

$$\frac{S}{v} = \frac{K_m}{V} + \frac{S}{V} + \frac{S^2}{VK_{ss}} \qquad (4)$$

where K_m = Michaelis constant, V = maximum initial velocity. Differentiating (4) with respect to S yields a linear relationship (5) between S and the tangent of the curve resulting from a plot of S/v against S.

$$\frac{\mathrm{d}(S/v)}{\mathrm{d}S} = \frac{1}{V} + \frac{2S}{VK_{ss}} \qquad (5)$$

The values for K_m, K_{ss} and V may be readily calculated from the slope intercept relationships obtained from the plots of equations (4) and (5). Performing the necessary arithmetic we obtain the following values: K_m = 35 mM, V = 0·35 mgm. fructose/0·2 ml. enzyme/half an hour and K_{ss} = 3,900 mM. It will be noticed that the first two values agree closely with the values obtained previously[2] for these two constants. Substituting the derived figures for the three constants into equation (4) a calculated value for the initial velocity v may be obtained. This is shown by the smooth curve in Fig. 1.

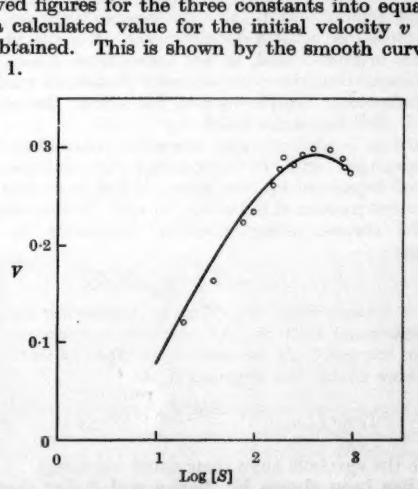


Fig. 1. Plot of initial velocity (mgm. fructose/0·2 ml. enzyme/½ hr.) against the logarithm of substrate concentration. The open circles represent experimental points while the smooth curve was calculated from equation (4)

The close correspondence between the experimental and the calculated curve tends to substantiate the original assumption that it is excess substrate which inhibits this particular enzyme. From the theory of the two-step reaction systems[5] another point of interest may be derived from the present work. If the enzyme has the same affinity for both the first and second substrate molecules, the value of the quotient $K_{ss}/4K_m$ will be unity. If the affinity is greater for the first substrate molecule, the ratio will be greater than unity. It is obvious that the second alternative holds in the present case, namely, that dextransucrase has a much greater affinity for the first substrate molecule than it does for the second.

W. Brock Neely

Biochemical Research Laboratories,
The Dow Chemical Company,
Midland, Michigan.
July 18.

[1] Hehre, E. J., *J. Biol. Chem.*, **163**, 221 (1946).
[2] Neely, W. B., *J. Amer. Chem. Soc.*, **80**, 2010 (1958).
[3] Somogyi, M., *J. Biol. Chem.*, **160**, 61 (1945).
[4] Nelson, N., *J. Biol. Chem.*, **153**, 375 (1944).
[5] Bray, H. G., and White, K., "Kinetics and Thermodynamics in Biochemistry", 227 (Academic Press, Inc., New York, 1957).

Determination of the Mass Thickness of Cell Membranes from their Electron Micrographs

In this communication, we give values of the mass thicknesses of the cell membranes of *Bacterium coli*, human red blood corpuscle and *Leishmania donovani* estimated as follows.

Purified normal cells in each case were disrupted by chemical means to remove the cellular contents. The cell membranes, after separation, were collected on collodion-coated grids, and after drying only collapsed cell membranes remained. These were then examined with a Siemens 'Elmiskop I' electron microscope at 60 kV. with an objective aperture angle of $\sim 10^{-3}$ radian, and afterwards photographed on Ilford Process plates. After due processing of the plates, the photographic densities D_t and D_0 in the imaged region and in the background respectively were measured with a densitometer. For the photographic negative used, it was found from a previous experiment that the γ value under the above working and processing conditions was 2·8 within the photographic density-range 1·5–3·0.

Since in a photographic negative containing both the specimen and the supporting film regions, the time of exposure was the same, it followed that the respective measured densities D_0 and D_t were related to the corresponding electron intensities by the relation:

$$D_0 - D_t = 2{\cdot}8 \log_{10} (I_0/I_t) \qquad (1)$$

It is known from the electron scattering formula of Liesegang[1] that in the electron microscope the image intensity I_t is related to the object mass thickness ρx by the expression,

$$I_t = I_0 \exp\left(-\frac{N_A}{\pi} \cdot \frac{Z^{4/3}}{A} \cdot \lambda^2 \cdot \rho x\right) \qquad (2)$$

where the symbols have their usual meanings.

It has been shown by Zeitler and Bahr[2] that for various biological materials equation (2) can be written as:

$$I_t/I_0 = \exp(-4{\cdot}43 \times 10^4 \rho x) \qquad (3)$$

for 60 kV. electrons. Combining equations (1) and (3), ρx is given by:

$$\rho x = \frac{D_0 - D_t}{2{\cdot}8} \times 52{\cdot}4 \ \mu\text{gm.cm.}^{-2} \qquad (4)$$

The relevant data and the corresponding mass thicknesses of the cell membranes are given in Table 1.

Table 1. Mass Thickness of Cell Membranes

Specimen	Photographic density		Mass thickness of the cell membrane ρx (μgm.cm.$^{-2}$)	Computed thickness assuming $\rho = 1$
	D_t	D_0		
(Cell membrane) *Bacterium coli*	2·29	2·49	1·86	186 A.
Human red blood cells	1·58	1·85	2·51	251 A.
L. donovani	2·54	2·88	3·16	316 A.

The mass thickness of the cell membrane, as calculated from equation (4) with the help of the data in columns (2) and (3) above, is really the density multiplied by twice the membrane thickness, as the two membranes collapse together and provide the photographic density D_t. So the mass thickness of a single membrane of a cell would be half that of the value estimated from equation (4) and has been recorded in column (4).

Assuming the value of unity for ρ, the density of the material composing the membranes, the respective membrane thicknesses are as recorded in column 5. These values are to be compared with the thickness values of (100–150 A.), (120–300 A.) and 250 A. respectively reported by other workers[3–5].

Thanks are due to Prof. N. N. Das Gupta for his kind help and interest in this work and to Mrs. J. Chakraborty, and Messrs. S. B. Bhattacharjee and K. N. Bhattacharjee for their help in preparation of the specimens. Thanks are also due to the Ministry of Scientific Research and Cultural Affairs, Government of India, for financial assistance.

M. L. De
P. Sadhukhan

Biophysics Division,
Institute of Nuclear Physics,
Calcutta-9.
July 21.

[1] Liesegang, S., *Z. Phys.*, **132**, 183 (1952).
[2] Zeitler, E., and Bahr, G. F., *Exp. Cell Res.*, **12**, 44 (1957).
[3] Salton, M. R. J., *et al.*, *Biochim. Biophys. Acta*, **7**, 177 (1951).
[4] Ponder, E., in "Medical Physics", **1**, 1203, edit. by Glasser, O. (1951).
[5] Pyne, C. K., *Exp. Cell Res.*, **14**, 388 (1958).

A New Method of tracking Artificial Earth Satellites

Existing instruments for making precise trajectory observations on artificial Earth satellites generally employ photographic techniques, a good example being the Schmidt–Baker–Nunn cameras of the Smithsonian Astrophysical Observatory. Since the launching of *Sputnik* 2, we have been experimenting with optical tracking by a photo-electric method which appears capable of adequate sensitivity and a precision comparable with that of astronomical observations, and thus high enough for observing the non-secular perturbations of a satellite orbit. The principal

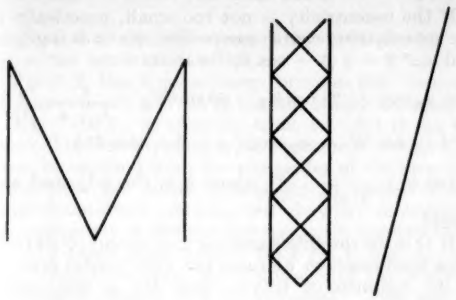


Fig. 1. Slit systems which can be used to determine the line of sight of a satellite: (*a*) the simplest system which has been used; (*b*) a version giving greater precision

advantage of the method is the simpler design of the optical system since a long focal length can be used, unlike the photographic method where a short-focus lens is required. The correction of lens aberrations is thereby rendered much easier. A performance in many ways comparable with the Schmidt–Baker–Nunn camera has been obtained with a lens having a 5-in. diameter aperture and 14-in. focal length.

The method used is as follows: A system of slits is placed in the focal plane of a lens and, behind them, a photo-multiplier. As the satellite, which must be sunlit, moves across the sky, its image moves across the slits and produces a series of pulses. These enable the position of the track in the sky to be determined if the orientation of the lens axis is also known. This can be found by stellar observations. If the azimuth and elevation of the satellite are expressed as power series in time of the nth degree, the minimum number of slits required is $(2n + 2)$. We have so far mainly used what is perhaps the simplest system possible, of the form shown in Fig. 1*a*. It is here necessary to assume that the apparent path of the satellite is a straight line, the satellite moving with constant angular velocity. The azimuth and elevation of two points on the track, spaced at a distance equal to the angular width of the slit system, are then found. The estimate of the angular velocity so obtained is of relatively poor precision unless widely-spaced slits are used, so the best method of making accurate measurements of angular velocity is to make a number of observations over a large part of the trajectory. The error caused by the assumption of a linear track can be reduced by making the slit system sufficiently narrow, but in order to cover a reasonably large part of the sky a rather more complicated slit system such as that shown in Fig. 1*b* must then be used. The extra slit is in this case used to identify the element of the system over which the track has passed.

The limiting satellite magnitude which can be detected is determined by the shot noise in the photomultiplier due to steady illumination of the slits by skylight and starlight, which generally exceeds the noise due to the dark current of the cell. When the bandwidth of the recording system is an optimum, the signal-to-noise ratio is proportional to $(\sigma A/B\omega\theta)^{1/2}$, where σ is the photocathode sensitivity, A the lens aperture area, B the sky brightness, ω the angular velocity of the satellite and θ the length of the slits. The width of the slits does not appear in this expression, so that the accuracy and sensitivity of the system can be adjusted independently.

The much lower angular velocity of stars makes possible discrimination against the signals they produce. The image of star or satellite is made just to fill the width of the slits, by defocusing if necessary, and the differentiating time constants of the recording system are then so chosen as to discriminate strongly against the slowly rising pulses produced by stars.

We have so far used two different telescopes, with apertures of 2 and 5 in. The peak noise-level of the larger instrument, produced by the midnight sky in July, is equal to the signal from a 10th magnitude object. Each instrument has a precision of about 15 sec. of arc, but different methods of calibration with stars are used. On the 2-in. telescope, the photocell must be removed and replaced by a photographic film. The slits are so constructed that a large area of sky around them can be photographed to obtain the orientation of the axis. The other telescope is fitted with accurate scales of azimuth and elevation which are calibrated by allowing stars to trail across the slits (the time constants of the recording system being adjusted to allow this). The accuracy of the first instrument is limited by the optical system, that of the second, on which the centre of the image can be located to 2 sec. of arc, by the mechanical construction.

No reason is apparent why a suitably designed optical system should not give a very substantially higher accuracy than these telescopes. A rather larger aperture is also easily obtained and would give a useful improvement in sensitivity. We now propose to build such equipment, and to exploit more fully the potentialities of this method.

The signal-to-noise ratios we have observed indicate that objects as bright as *Sputnik* 3 could be detected by this method during the daytime, using a field of view of about $\frac{1}{2}°$. We have not yet attempted to do this.

A record obtained on July 23 from the rocket of *Sputnik* 3 with the 5-in. telescope is reproduced in Fig. 2. Five successive passages of the satellite across the slits were recorded, the telescope having been moved progressively across the sky. There are some additional pulses on the record which occurred when the telescope was being moved. The slit system was a simplified form of that shown in Fig. 1*b*, so that a fifth pulse occurs on some sets. The marked variation of brilliance of the satellite is clearly shown. The timing marks are 1 c./s. pulses from a chronometer. This record can be measured to an accuracy equivalent to 1 min. of arc. During this phase of the work we used a low recorder speed with a consequent loss of timing accuracy. We are now using recorder speeds more consonant with the accuracy of the optical system. Figs. 3*a* and 3*b* show the two telescopes.

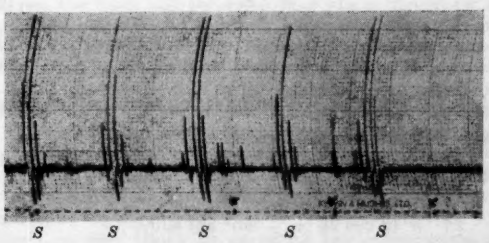
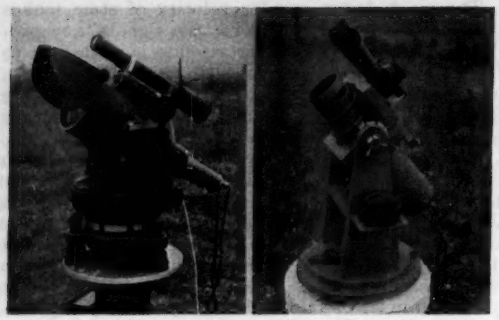


Fig. 2. A record of *Sputnik* 3 rocket. The groups of pulses marked *S* are due to the satellite, the remainder having been produced as the telescope was moved



(a) (b)

Fig. 3. The two tracking telescopes: (a) 5 in. and (b) 2 in. aperture, respectively

The equipment has been operated on a site at the B.B.C. Receiving Station, Tatsfield. We are greatly indebted to the B.B.C. for the many facilities which they have afforded us. We gratefully acknowledge also a grant from the Royal Society.

This work could not have been carried out without the assistance of Drs. R. L. F. Boyd and R. F. Stebbings, and Messrs. K. Maxwell and A. Thompson in operating the telescopes.

A. P. Willmore

Department of Physics,
University College, London, W.C.1.
Sept. 10.

Scale Height of the Upper Atmosphere

Several formulæ have been published recently for calculating the effect of air resistance on orbits of artificial Earth satellites. The latest and most complete are by King-Hele and Leslie[1]. Nearly all these formulæ are valid over a somewhat limited range of eccentricity and are based on a spherical Earth. The effect of ellipticity is by no means negligible and can be corrected for without much additional complication.

If the scale height of a homogeneous isothermal atmosphere is H at a distance r from the centre of the Earth, then r^2/H is practically constant and independent of latitude.

If R is the Earth's local radius then:

$$\rho = \rho_0 \exp\left\{-\frac{r^2}{H}\left(\frac{1}{R} - \frac{1}{r}\right)\right\} \quad (1)$$

If e is the eccentricity of a satellite orbit, r_p is the radius at perigee, θ the anomaly, i the inclination, φ the angle from apex to perigee and ε the Earth's ellipticity, then:

$$r = \frac{r_p(1+e)}{1+e\cos\theta} \quad (2)$$

$$R_p = R_{\max.}(1 - \varepsilon\sin^2 i\cos^2\varphi) \quad (3)$$

$$R - R_p = R\varepsilon\sin^2 i\sin\theta\sin(2\varphi+\theta) \quad (4)$$

Let $\frac{R}{H_0}\varepsilon\sin^2 i = \beta$, then omitting terms which average out around the orbit:

$$\rho = \rho_p \exp\left\{-\frac{e}{1+e}\cdot\frac{r_p}{H_p}(1-\cos\theta)\right\} \times \left\{1 + (\beta\cos 2\varphi + \frac{\beta^2}{2}\sin^2 2\varphi)\sin^2\theta + \left(\frac{\beta^2}{2}\cos 4\varphi + \frac{\beta^3}{2}\sin^2 2\varphi\cos 2\varphi\right)\sin^4\theta + \ldots\right\} \quad (5)$$

If the eccentricity is not too small, practically all the retardation occurs near perigee, $\sin^4\theta$ is negligible and $\sin^2\theta = 2(1-\cos\theta)$, so that:

$$\rho = \rho_p \exp\left\{\left(2\beta\cos 2\varphi + \beta^2\sin^2 2\varphi - \frac{e}{1+e}\cdot\frac{r_p}{H_p}\right)\times (1-\cos\theta)\right\} = \rho_p \exp\{-\psi(1-\cos\theta)\} \quad (6)$$

Let $\psi = \frac{e}{1+e}\cdot\frac{r_p}{h}$, where h is the adjusted scale height.

If Ω is the satellite's angular momentum, C its resistance coefficient, m its mass per unit frontal area and S its distance of travel, then for a non-rotating Earth:

$$\frac{\mathrm{d}(\log\Omega)}{\mathrm{d}S} = -\frac{C\rho}{2m} \quad (7)$$

The Earth's rotation reduces the airspeed by an almost constant fraction which can be allowed for by a change in ρ_0.

Also

$$\frac{\mathrm{d}e}{\mathrm{d}(\log\Omega)} = 2(\cos\theta + e) \quad (8)$$

$$\frac{\mathrm{d}r_p}{\mathrm{d}(\log\Omega)} = \frac{2r_p}{1+e}(1-\cos\theta) \quad (9)$$

$$\frac{\mathrm{d}S}{\mathrm{d}\theta} = \frac{r_p(1+e)}{(1+e\cos\theta)^2}\sqrt{(1+2e\cos\theta+e^2)}$$

$$= r_p(1+e)\{1 - e\cos\theta + \frac{e^2}{2}(1+\cos^2\theta) - \frac{e^3}{2}(3\cos\theta - \cos^2\theta) + \ldots\}$$

$$= r_p(1+e)\times \left\{1 - e^3 - (e-e^2)\cos\theta + \frac{\delta^2 e^2}{2} + \frac{3\delta^2 e^3}{2} - \frac{\delta^3 e^3}{2}\right\} \quad (10)$$

$\delta = 1 - \cos\theta$

From (5) it is clear that the mean value of δe in the significant part of the orbit is of the order of $(1+e)\,h/r_p$, which is probably less than 0·01, so that $\delta^3 e^3$ will be negligible.

If then e^4 is negligible:

$$\frac{\mathrm{d}S}{\mathrm{d}\theta} = r_p(1+e)\{1 - e^3 - (e-e^2)\cos\theta\} \quad (11)$$

Using (6), (7), (11) and (8) or (9), exact solutions are obtainable for mean values around the orbit:

$$\frac{\mathrm{d}e}{\mathrm{d}\theta} = -\frac{C\rho_p r_p(1+e)(1-e^2)}{m}\times \left\{\left(1+\frac{h}{r_p}\right)I_1(\psi) + e^2 I_0(\psi)\right\}\exp(-\psi) \quad (12)$$

$$\frac{\mathrm{d}r_p}{\mathrm{d}\theta} = -\frac{C\rho_p r_p^2(1+e)(1-e^2)}{m}\times \left[I_0(\psi) - \left\{1 + \frac{h}{(1+e)r_p}\right\}I_1(\psi)\right]\exp(-\psi) \quad (13)$$

If $\psi > 2$ then, with an error of less than 1·5 per cent if $2 < \psi < 4$ and of 0·5 per cent if $\psi > 4$, we have:

$$\frac{\mathrm{d}r_p}{\mathrm{d}(\log e)} = \frac{h}{2(1+e)}\left(1 + \frac{2}{3}\cdot\frac{h}{r_p}\right)\times \left(1 + \frac{3}{4\psi} + \frac{3}{4\psi^2} + \frac{3}{2\psi^3}\right) \quad (14)$$

Since h is not constant this must be integrated numerically; however, integration is made easier by

the fact that $d(e^2)/d\theta$ varies very little during the life of an artificial satellite.

If $\psi < 2$, the approximate formula (14) becomes very inaccurate and $\sin^2\theta$ can no longer be equated to $2(1 - \cos\theta)$, so that (5) must be used in its full form. The eccentricity, e, however, is so small that it can be omitted from the remainder of the formulæ.

Solutions are easily obtainable in terms of the Bessel functions I_0 and I_1, but they are rather long and only apply to the last few days of a satellite's life.

If the mean temperature between R and r_p falls from equator to poles the ellipticity of the surfaces of constant density will be increased. This can be allowed for by a change in ε.

For a mixture of gases of different molecular weights it is necessary to sum the values of (12) and (13) for the components. Values of H obtained from satellites with different perigee radii may give some information about the change of composition with height.

C. H. Bosanquet

'Dingestow',
Bishopton Road West,
Stockton-on-Tees.
July 17.

[1] King-Hele, D. G., and Leslie, D. C. M., *Nature*, **181**, 1761 (1958).

Thermo-electric Observations on Grey Selenium

The thermo-electric power of grey selenium has been accorded considerable attention in recent years, and Henisch and Francois[1], among others, have carried out accurate measurements and discussed their results in terms of a simple model. We wish to report some thermo-electric results, obtained in the course of an investigation of the photo-catalytic properties of this modification of selenium, which are at variance both with common experience and with these workers' model.

It seems to be experimentally well established that selenium is almost unique among semiconductors in having a thermo-electric power with a positive temperature coefficient: this can be explained[1] by assuming that the activation energy of the semiconductor is so small that most of the impurity centres are normally ionized. By submitting selenium to repeated vacuum distillations followed by recrystallization, we have prepared spectrographically pure samples, from which a few substantially monocrystalline ingots were grown by the Bridgman technique. Most of the ingots, however, consisted of bundles of large grains all having their c-axis parallel to the growth direction (oriented polycrystals). Thermo-electric power measurements on ingots of both types, extending over many months, yielded results of marked qualitative difference. As shown in Fig. 1, the oriented polycrystal specimen has a thermo-electric power which increases with temperature, and further exhibits hysteresis and secular changes, since the scatter of the points is much worse than the measurement error (of the order of 1 per cent at all but the lowest temperatures). Both these features have been reported to be of common occurrence with monocrystalline as well as with polycrystalline samples[2]. We found, however, that monocrystals showed a thermo-electric power quite independent of temperature, and insensitive to thermal history. The scatter of results below $-100°$ C. is due to the rapidly increasing resistance of the specimen (upwards of 10^{10} ohms), which impaired the precision of the measurement, carried out by means of an integrating potentiometric circuit already described[3].

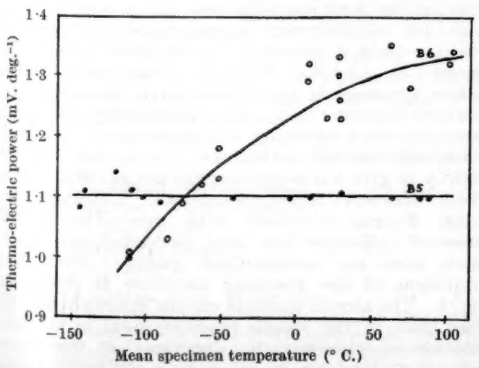


Fig. 1. Thermo-electric power of grey selenium crystals. *B5*, single crystal; *B6*, oriented polycrystal

One of us (J. I. C.) is indebted to the Engineer-in-Chief of the General Post Office for permission to make use of this information.

J. I. Carasso

Post Office Research Station,
Dollis Hill, London, N.W.2.

R. W. Pittman

Birkbeck College,
University of London. Aug. 7.

[1] Henisch, H. K., and Francois, M., "Semiconducting Materials" (Butterworth, London, 1951).
[2] Henkels, H. W., *Phys. Rev.*, **77**, 734 (1950). Plessner, K. W., *Proc. Phys. Soc.*, A, **64**, 673 (1951).
[3] Carasso, J. I., and Pittman, R. W., *J. Chem. Soc.*, 1084 (1956).

New Supersonic Phenomena

Polarized light has been used for determining the propagation of stress waves in solids for some time. We have employed it to study the propagation of stress waves in glass and plastics and have found what we believe to be evidence of new supersonic phenomena. The experimental arrangement follows classical lines, using 'Polaroids' and quarter-wave plates that give circularly polarized light through the transparent sample. For illumination, we used a 1530 *PI* discharge tube (General Radio) with an effective flash duration of 2 μsec. The transparent sample was loaded by exploding small amounts of lead azide with an electric 'bridge'. The timing between the flash and the explosion was achieved by a suitable electric timer which allowed a variation of the delay from zero to 30 μsec. It is well known that shock loading causes a compressional and a shear wave to be propagated in the material, both of which essentially follow the so-called Huygens construction.

However, our 'single shot' tests showed that, far in advance of the compressional wave, which has a speed of propagation of 5,500 m./sec. in glass, dark lines occurred at the far corners of the rectangular specimen at about 45°. These dark lines appear as much as five times as early as the compressional wave could have reached the point. We also investigated 'meeting shots' where two explosive charges at the centres of the short ends of a sample of glass,

Fig. 1

4 in. × 6 in., were exploded in series. When the delay was such that the compressional waves were propagated about 1 in. into the sample, a very sharp pattern of parallel lines was observed in the centre of the sample much in advance of the compressional wave. Similarly, parallel line patterns were observed near the sides of the sample, as is seen in Fig. 1. The conditions of operation were: 10·6 μsec. after explosion on a glass plate 80/1,000 in. or 2 mm. thick using 13 mgm. lead azide. Similar photographs have been made in colour and have shown that the blue interference patterns have a completely different colour from the reddish-yellow one of the explosion.

Both the 'single shots' and the 'meeting shots' give evidence of phenomena occurring up to about five times faster than the compressional speed of sound, or up to a speed of about 30,000 m./sec. in glass. Similar investigations made on plastics, for example, methylmethacrylate ('Lucite') and *CR*39 resin, showed basically the same phenomena but much less distinctly, apparently damped out. We have investigated the possibilities of experimental errors causing these theoretically unexpected wave phenomena in solids but have not been able to find any. The phenomena photographed are faint as compared with the intensity of the compressional wave; however, they seem to be standing waves, whereas the compressional waves move with the velocity of sound. Therefore, the use of a 2 μsec. flash which gives a blurred picture of the compressional wave results in sharply defined traces of the supersonic pattern. The charge used seems to be an optimum for the detection of the phenomena in glass. The patterns depend on the thickness of the sample: they are sharper with thin plates, their spacing increasing linearly with the thickness.

Experiments using an electrical delay line between the (parallel) charges show a shift of the meeting pattern equivalent to the speed of the compressional wave.

The patterns described are completely different from the 'regular' ones obtained by the Huygens construction and are essentially rectilinear and parallel to the sides of the samples. The phenomena could be caused by a very fast wave propagated on the surfaces of the sample, with the two compressional waves generated interfering to produce the pattern by exciting thickness vibrations of the plate. We have found no evidence that these phenomena move at all. The estimated speeds given above are deduced from observing the phenomena ahead of the compressional wave and are not really measurements of velocities; rather they represent a lower limit for the velocity of propagation of these supersonic phenomena.

I have also observed the formation of cracks in glass progressing with the speed of the compressional wave, and even ahead of it, as compared to the crack propagation speed of $\frac{1}{2}\sqrt{E/\rho}$ generally accepted. The cracks are irregular, occurring apparently at flaws in the sample, again departing from the usual radial cracks in impact loading. These observations tend to confirm the reality of the new phenomenon.

Further details of this work will be reported elsewhere. It is being supported by the Office of Ordnance Research, Duke University, Durham, North Carolina.

Wladimir Philippoff

Franklin Institute Laboratories
for Research and Development,
Philadelphia, Pennsylvania.
Aug. 27.

Crystal Structure of β-Wollastonite

β-Wollastonite ($CaSiO_3$) comprises both triclinic wollastonite and monoclinic parawollastonite[1]. These forms are not easily distinguishable except by single-crystal X-ray work, since they differ only in the reflexions with k odd, and these are always weak. A new type of infinite-chain silicate structure has recently been proposed[2] for β-wollastonite from X-ray crystallographic work on projections. The three-dimensional work on parawollastonite from Crestmore, California, which is reported here confirms this type-structure.

The cell parameters of parawollastonite are: $a = 15{\cdot}417 \pm 0{\cdot}004$ A., $b = 7{\cdot}321 \pm 0{\cdot}002$ A., $c = 7{\cdot}066 \pm 0{\cdot}002$ A., $\beta = 95°\ 24' \pm 3'$, $G = 2{\cdot}922$, $Z = 11{\cdot}95$ formula units. The systematic absences are: in hkl, $(2h + k) = (4n + 2)$, which can only apply to terms with k even, and in $0k0$, $k = (2n + 1)$. The space group is $P2_1$, with $6CaSiO_3$ in the asymmetric unit of half the cell. The absence in hkl implies further symmetry, in that there must be equivalent, non-lattice, points at 0,0,0; $\frac{1}{2}$, $\frac{1}{4}$, 0. The positions of equivalent atoms are thus (0, 0, 0; $\frac{1}{2}$, $\frac{1}{4}$, 0) + x, y, z; $\bar{x}$, $\frac{1}{2} + y$, $\bar{z}$; so that only three units of $CaSiO_3$ are crystallographically independent. No centre of symmetry can be assumed; physical tests for this were inconclusive.

The hkl reflexions with k even are relatively strong, which implies a concentration of atoms about the planes $(2n + 1)b/8$. If these planes have limited mirror symmetry[3], the space group becomes the centrosymmetric $P2_1/a$. After preliminary work on a chain structure assuming this space group, on which refinement was not satisfactory, atoms were shifted slightly to give a non-centrosymmetrical structure on which refinement is progressing well. A three-dimensional Fourier synthesis with more than 1,300 observed reflexions has been computed, on which there were no unidentifiable peaks. The [001] projection of the resulting structure is shown in Fig. 1. The atomic maxima on this Fourier synthesis were close to the atomic positions used in the calculation of phases; the directions of the shifts indicate no tendency to return to a centrosymmetric structure.

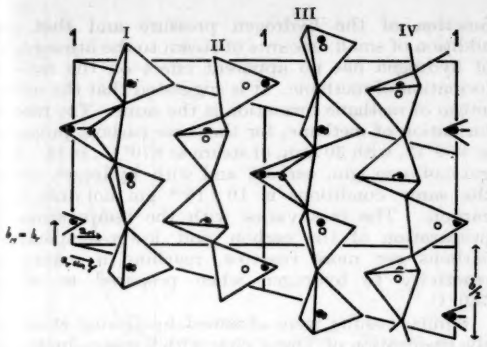


Fig. 1. Parawollastonite structure projected down [001]. ●, calcium atoms; ○, silicon atoms; oxygen atoms at apices of tetrahedra. Axes of monoclinic cell have subscript M, of outlined triclinic cells subscript T

The parawollastonite structure has infinite chains of silicon tetrahedra parallel to the b-axis, as is suspected from its fibrous habit. The repeating unit of three tetrahedra in the chain consists of a pair of tetrahedra joined apex to apex, as in the Si_2O_7 group[4], alternating with a single tetrahedron with one edge parallel to the chain direction. The calcium co-ordination is irregular, though all calcium atoms are co-planar with four near oxygen O^{1-} atoms and have distorted octahedral co-ordination. The atom almost on the screw diad axis has seven oxygen atoms within 2·6 A. of it, one of which is already bonded to two silicon atoms. The other two calcium atoms have almost identical environments. At one apex of the octahedron is an oxygen O^{0-} already bonded to two silicon atoms; at the opposite apex is an oxygen O^{1-} bonded only to one silicon atom. In these octahedra there are two oxygen O^{1-} atoms bonded only to two calcium atoms, instead of three, and to one silicon atom. Pauling's rules are thus satisfied by the addition of charges from the six oxygens around Ca^{2+} of $(3 \times \frac{1}{3} + 2 \times \frac{1}{2} + 1 \times 0) = 2$.

The close relationship between the β-wollastonites is shown in Fig. 1, where two wollastonite cells have been outlined on the one parawollastonite cell; the c-axes are equal. Chains III and IV are not in the same relative orientation as chains I and II in parawollastonite: the symmetry of wollastonite requires that they should be, which can be achieved by shifting chain IV by $b/2$. Since the difference between parawollastonite and wollastonite depends only on a simple packing modification, the close intergrowth of the two is easily explicable.

This work was undertaken at Birkbeck College, London, on an extra-mural grant to the College from the Building Research Station.

JOAN TOLLIDAY

Akers Research Laboratories,
Imperial Chemical Industries, Ltd.,
The Frythe,
Welwyn, Herts.
Aug. 8.

[1] Peacock, M. A., *Amer. J. Sci.*, **30**, 495 (1935).
[2] Dornberger-Schiff, K., Liebau, F., and Thilo, E., *Acta Cryst.*, **8**, 752 (1955). Buerger, M. J., *Proc. U.S. Nat. Acad. Sci.*, **42**, 113 (1956). Mamedov, Kh. S., and Belov, N. V., *Doklady Akad. Nauk S.S.S.R.*, **107**, 463 (1956).
[3] Dornberger-Schiff, K., *Acta Cryst.*, **9**, 593 (1956).
[4] Smith, J. V., *Acta Cryst.*, **6**, 9 (1953).

Tetrahedral Co-ordination in Ni(II)

Two forms of Ni(II) compounds have been recognized for a long time, the green paramagnetic forms and the (yellow) diamagnetic forms. The nature of these has been described in terms of electronic structure by Pauling[1], as a paramagnetic 6-co-ordinate form with two unpaired electrons and a square planar form with hydridized orbitals leading to diamagnetism through electron pairing. The magnetic criterion has been completely satisfactory in differentiating these two. There is another 4-co-ordinate configuration theoretically possible, namely, the tetrahedral, which also would have two unpaired electrons. No obvious criterion presents itself for differentiation of this from the octahedral 6-co-ordinate condition.

There are occasional Ni(II) compounds which are blue, and some of these have been studied magnetically by Lifschitz, Bos and Dijkema[2]. The conclusion of these workers was that these compounds were tetrahedral. More recent reports on this identification of possible tetrahedral Ni(II) compounds have been from workers interested in geometrical properties of organic chelating agents, and from those interested in the ligand field type of explanation of transition element spectra and binding. The detailed calculations carried through on this latter basis have apparently not given any clear assignment by spectral relations or other obvious criterion (for example, Maki[3]).

Low[4] has investigated the paramagnetic resonance and optical spectra of Ni(II) in magnesium oxide (MgO) crystals, with a rigid octahedral symmetry imposed by the crystal structure. From his work, the relatively strong sharp peak of the Ni(II) absorption spectrum which is found normally around 400 mμ is due to a transition $^3F(\Gamma_2)$–$^3P(\Gamma_4)$. The highest of the three ^3F levels into which the free-ion ^3F ground-state is split is Γ_4. In the inversion of levels in changing to tetrahedral field[4,5], the Γ_2 level as ground-state would be replaced by a Γ_4 level. As this $^3F(\Gamma_4)$ should no longer give a relatively strong transition to the $^3P(\Gamma_4)$ level[6], as did the Γ_2 ground-state, the corresponding 400-mμ absorption peak should vanish.

In studies of the absorption spectra of inorganic salts in non-aqueous media, in which this Laboratory has had an interest, experiments have been performed in tributyl phosphate and in acetone media which bear on this question. In acetone, for example, very dilute solutions of nickelous perchlorate (about 2×10^{-4} M—concentrations are chosen to minimize precipitation of nickelous chloride after addition of chloride) are green, and show the characteristic peak at about 410 mμ. Addition of up to two equivalents of lithium chloride intensifies the peak (as it does those at longer wave-lengths), and shifts it to about 423 mμ. Further additions of chloride, however, while still intensifying the peaks at longer wavelengths, cause the 425-mμ peak to diminish in intensity, and by a composition with four chlorides per nickel, essentially to vanish. In the intermediate stages there is a suggestion that the peak may be splitting into two. The colour of the solutions is a deep blue, reminiscent of the blue cobalt colour, and the spectra at high chloride ratios (for example, 9 : 1) also somewhat resemble those of $CoCl_4^{2-}$. After some hours or a day, even these dilute solutions tend to deposit nickelous chloride. Similar observations were made in the tributyl phosphate solutions.

If a solvent such as *iso*propyl alcohol is used instead of the above, one gets only intensification of peaks even for anion–nickel ratios greater than two. This holds for both chloride and thiocyanate. It is interesting that study of continuous variations of these solutions shows a maximum apparent complexing of four anions per nickel[7]. This apparent limit might be due to problems of replacing further solvent groups, rather than an indicator of pure 4-co-ordination, as the alcohol is a stronger electron donor than acetone, and tends to maintain the higher co-ordination number of cations[8] (with iodide, co-ordination to six groups per nickel can be seen). It might be added that Ni(II) in fused nitrate salt melts is green, and that a blue colour develops on addition of chloride, with a spectrum similar to that of our blue acetone solutions (D. Gruen, private communication). Small amounts of nickel incorporated into solid Cs_2ZnCl_4 (tetrahedral $ZnCl_4^{2-}$) also show the same blue spectrum.

It is therefore suggested that the blue compounds studied by Lifschitz, Bos and Dijkema[2] were in fact tetrahedral, as is also the chloride (in excess chloride) in acetone and tributyl phosphate. The blue colour arises mainly by disappearance of the 410-mμ peak, as would be predicted from Low's[4] analysis of the levels for the Ni(II) ion in the octahedral crystalline field. One may venture to state the following generalization: paramagnetic nickelous compounds which are the normal green colour, or the spectra of which show the equivalent of the 410-mμ absorption peak of the green form, are to be presumed to be 6-co-ordinate, or at least to possess the electronic structure characteristic of the 6-co-ordinate state. Paramagnetic compounds of Ni(II) which fail to show this absorption peak (and which may be blue, if the colour is not masked by the ligand) are presumably tetrahedral, or have the equivalent electronic structure. Diamagnetic compounds have, of course, the square planar form.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

Leonard I. Katzin

Chemistry Division,
Argonne National Laboratory,
Lemont, Illinois.
Sept. 5.

[1] Pauling, L., "Nature of the Chemical Bond", 2nd ed. (Cornell University Press, 1949).
[2] Lifschitz, I., Bos, J. G., and Dijkema, K. M., *Z. anorg. u. allgem. Chem.*, **242**, 97 (1939).
[3] Maki, G., *J. Chem. Phys.*, **28**, 651 (1958); **29**, 162 (1958).
[4] Low, W., *Ann. N.Y. Acad. Sci.*, **72**, 69 (1958).
[5] Gorter, C. J., *Phys. Rev.*, **42**, 437 (1932).
[6] Kittel, C., and Luttinger, J. M., *Phys. Rev.*, **73**, 162 (1948).
[7] Katzin, L. I., and Gebert, E., Proc. All-day Conf., Chicago Section, Amer. Chem. Soc., November 23, 1951.
[8] Katzin, L. I., *J. Inorg. Nucl. Chem.*, **4**, 187 (1957).

Production of Methane from Carbon

The recent work of Blackwood and McGrory[1] has shown that methane is formed when carbon, in the form of coconut char, is allowed to react with steam under pressure. The rate of formation of methane is a linear function of the steam pressure and appeared to be independent of the partial pressure of hydrogen when the latter is small. A similar study[2] of the reaction of hydrogen and carbon under pressure at temperatures of 650–950° C. has shown that the rate of formation of methane is a linear function of the hydrogen pressure and that the addition of small amounts of steam to the atmosphere of hydrogen has no apparent effect on the rate of formation of methane. It is suggested that the mechanism of methane formation is the same. The rate of formation of methane, for the same carbon, prepared at 950° C., with 30 atm. of steam at 870° C., is 16×10^{-5} gm.mol./min./gm. carbon, and with hydrogen under the same conditions is 10×10^{-5} gm.mol./min./gm. carbon. The rate varies with the temperature of preparation of the carbon and lower-temperature carbons are more reactive, reaching a maximum reactivity to hydrogen when prepared at about 750° C.

Similar results were obtained by Goring *et al.*[3] in the gasification of 'Disco' char with a steam–hydrogen mixture at 870° C., their results showing that there is no significant change in the rate of formation of methane at a given temperature and pressure when the reactant gases are mixtures of steam and hydrogen in the ratios 50/50, 75/25 and 90/10. Their gasification-rate at 870° C. and 30 atm. pressure was approximately 33×10^{-5} gm.mol./min./gm. carbon, and later experiments in the same apparatus with similar char[4], using hydrogen only as the reactant gas, gave a rate of 40×10^{-5} gm.mol./min./gm. carbon. Wood charcoal, prepared at 870° C. from *Eucalyptus marginata*, when made to react with hydrogen under the same conditions of temperature and pressure, gave[2] a rate of formation of methane of approximately 45×10^{-5} gm. mol./min./gm. carbon.

It has been suggested[1] that the carbon–steam reaction is controlled by oxygen groups attached to the carbon and that the methane produced is formed by reaction of steam with adsorbed hydrogen, liberating methane and carbon monoxide. The formation of methane by reaction of hydrogen with carbon is believed to be controlled by oxygen groups, such as chromene or benzpyran, in the carbon structure[2], and it now appears that these may be effective in controlling methane production in both the carbon–steam and carbon–hydrogen reactions.

The formation of methane during the carbon–steam reaction is important technically since it results in a reduced heat requirement for the gasification of carbon with steam due to the exothermic nature of the reaction producing methane.

J. D. Blackwood

Division of Industrial Chemistry,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.
Sept. 4.

[1] Blackwood, J. D., and McGrory, F., *Aust. J. Chem.*, **11**, 16 (1958).
[2] Blackwood, J. D., *Aust. J. Chem.* (in the press).
[3] Goring, G. E., Curran, G. P., Tarbox, R. P., and Gorin, E., Pittsburgh Consolidated Coal Co. Library (Pennsylvania, 1951).
[4] Zielke, C. W., and Gorin, E., *Indust. Eng. Chem.*, **47**, 820 (1955).

Paper as a Carrier of Chromium Sesquioxide

Chromium sesquioxide (Cr_2O_3) is widely used for estimating feed digestibility[1] or fæces output[2] by ruminants, but such estimates may be subject to considerable errors because the concentration of this marker in fæces normally shows considerable diurnal variations even after prolonged regular administration. These variations are particularly obtrusive with grazing animals where the chromium sesquioxide, in

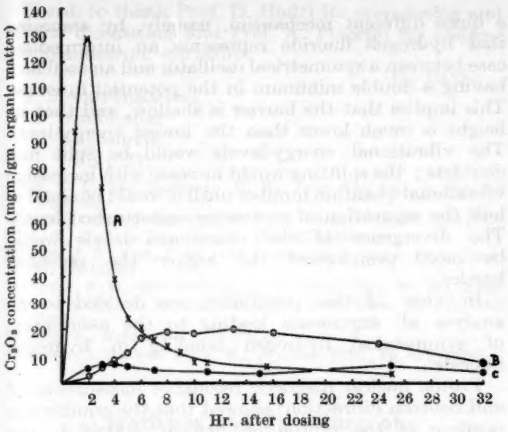


Fig. 1. Concentrations of chromium sesquioxide expressed as mgm./gm. organic matter in digesta drawn from the duodenum of a sheep following the administration of single doses of chromium sesquioxide: *A*, as the powder in a gelatin capsule; *B*, in paper; *C*, in plaster of Paris

this case used for estimating the output of fæces, is usually administered in concentrated powder form in gelatin capsules once or twice daily, and they probably arise primarily from an imperfect mixing of the oxide with digesta in the reticulo-rumen[3,4]. This view is supported by unpublished observations (by J. F. D. Greenhalgh) on the concentrations of chromium sesquioxide in the organic matter of digesta obtained from the duodenum of a sheep permanently cannulated at this point. As the variations in concentration during a period of regular dosing showed the same pattern and were greater than those found in the fæces, it was decided to study in a comparably cannulated sheep the passage of single doses of oxide powder, each given in a gelatin capsule and in amount large enough to give measurable concentrations over a considerable period of time. Samples of digesta were drawn from the duodenum at intervals beginning 1 hr. after dosing. Results from a typical run where 8 gm. were given are shown in Fig. 1 (line *A*) and indicate that a large part of the dose had passed from the stomachs within 4 hr. of administration. The probable explanation is that the capsule container dissolved quickly in the anterior rumen or reticulum[3] and that local concentrations of chromium sesquioxide in these regions[4] were rapidly transferred through the reticulo-omasal orifice.

Properly to fulfil its function as a marker, chromium sesquioxide should be cleared from the reticulo-rumen at a rate as nearly as possible equivalent to that of the food dry matter, or any of its constituents under study. Since this condition does not appear to be met by dosing with capsules containing loose oxide, some method of obtaining a slower and more regular release of chromium sesquioxide into digesta appears desirable. An attempt to do this has been made by incorporating the oxide in paper. A small quantity of paper was made by beating chromium sesquioxide in a 3 per cent stock (that is, 97 per cent water) of fully bleached sulphite wood pulp to which was added aluminium sulphate (paper-makers' alum) at 1 per cent of the dry matter. With the method employed it was found possible to obtain a paper containing 20–30 per cent chromium sesquioxide in the dry matter. It was found at this stage that Edin[5] had already suggested the use of a material termed 'chrome-cellulose' for determining the digestibility of rations consisting wholly of roughage. This material, resembling blotting paper, was prepared from a mixture of chromium sesquioxide and paper pulp, but apparently aluminium sulphate was not added. The 'chrome-cellulose' was cut into small strips and mixed with the chopped fodder, but it does not appear to have been tested or used to any large extent. In our experiments, which were concerned primarily with the development of a technique for estimating the output of fæces by grazing animals, the required amount of dry sheet, containing approximately 8 gm. chromium sesquioxide, was cased in gelatin capsules for dosing. It was tested by the rapid method afforded by the examination of digesta passing through the duodenum and one set of results is shown by line *B* in Fig. 1. There was no sign of a rapid passage of chromium sesquioxide through the stomachs; instead concentrations of the oxide steadily increased for 8 hr. after dosing and then remained at approximately the same level for at least a further 8 hr. before slowly declining.

A 'slow-release capsule' devised by Pigden and Brisson[6], which is claimed to reduce variations in concentrations of chromium sesquioxide in fæces, has also been tested. This capsule consisted of equal parts of chromium sesquioxide and plaster of Paris and was cast in a gelatin capsule. Its administration gave the results shown by line *C* in Fig. 1. Again there was no sign of a rapid passage of the oxide, and concentrations remained at approximately the level reached 2 hr. after administration for at least a further 40 hr.

Both methods of administration, in paper or in plaster of Paris, appear to be superior to the administration of the oxide in powder form, but it is believed that chromium sesquioxide paper possesses very considerable advantages. It was found by microscopic examination, using polarized light, that the effect of the aluminium sulphate was to attach the individual oxide particles to the cellulose fibres of the paper so that relatively few free particles were to be found after agitation in water. In addition a large proportion of the oxide appeared still to be attached to partially digested cellulose fibres and closely associated with organic debris in the duodenum. In this respect chromium sesquioxide is equivalent to a naturally occurring marker such as lignin, but possibly without the chief disadvantage of the latter, which appears to be the slower digestion and rate of passage through the alimentary tract of those fractions of the feed containing lignin in greatest concentration[7]. On the other hand, neither the oxide from the ordinary capsule nor that derived from the plaster of Paris capsule showed any marked degree of association with organic matter.

It is considered that the general pattern of the passage of chromium sesquioxide derived from the digestion of the paper, illustrated in Fig. 1, might more nearly approach that of the products of digestion of the food than the passage of the oxide derived from the slow erosion of a mineral matrix although, as has been pointed out elsewhere[4], it is unlikely that any marker can exactly parallel the behaviour of 'dry matter' as such in the gut.

Work is in progress to determine the optimum composition of chromium sesquioxide paper and to discover the pattern of excretion in fæces.

We thank Dr. P. Hobson of the Rowett Research Institute for carrying out the microscopic examinations. One of us (J. F. D. G.) is in receipt of

a Drummond Junior Fellowship for Research in Nutrition.

J. L. Corbett
J. F. D. Greenhalgh

The Rowett Research Institute,
Bucksburn,
Aberdeenshire.

A. P. MacDonald

C. Davidson and Sons, Ltd.,
Mugiemoss Mills,
Bucksburn,
Aberdeenshire.

Aug. 26.

[1] Edin, H., Kihlen, G., and Nordfeldt, S., *LantbrHogsk. Ann.*, **12**, 166 (1944).
[2] Raymond, W. F., and Minson, D. J., *J. Brit. Grassl. Soc.*, **10**, 282 (1955).
[3] Balch, C. C., Reid, J. T., and Stroud, J. W., *Brit. J. Nutr.*, **11**, 184 (1957).
[4] Corbett, J. L., Greenhalgh, J. F. D., Gwynn, P. E., and Walker, D., *Brit. J. Nutr.*, **12**, 266 (1958) and unpublished observations.
[5] Edin, H., Fran Centralanstalten för försöksväsendet på jordbruksområdet. Husdjursavdelningen No. 50 Med. 309 (Stockholm, 1926).
[6] Pigden, W. J., and Brisson, G. J., *Canad. J. Anim. Sci.*, **37**, 185 (1957).
[7] Kane, E. A., Jacobson, W. C., and Moore, L. A., *J. Nutr.*, **47**, 263 (1952).

The Problem of Negative Anharmonicity and the Nature of the Hydrogen Bond in Potassium Hydrogen Fluoride

There are many short hydrogen bonds which have been claimed to be symmetrical, but it is only in the case of potassium hydrogen fluoride that all the experimental evidence indicates that the proton is central. Yet in this substance there are still some problems to be cleared up, one of them being the hypothetical divergence of the protonic vibrational levels. Besides, as will be shown, the experimental results, which were thought to be explainable only in terms of a symmetrical model, may be explained in another way.

Cote and Thompson[1] explained the whole spectrum of the hydrogen fluoride ion between 1,225 cm.$^{-1}$ and 6,196 cm.$^{-1}$ in terms of the selection rules which would be expected for a linear symmetrical structure ($D_{\infty h}$). They found an apparently large negative anharmonic coefficient for the overtone and combination bands of the asymmetric stretching vibration frequency. Following a suggestion of Pitzer and Westrum[2], they explained this divergence of the protonic vibrational levels by assuming a fourth-power potential field: $V(x) \propto x^4$.

However, it can be generally shown that for fields where the potential energy varies for small displacements as the nth power of the displacement (n being a positive number), the isotopic ratio becomes $\nu_H/\nu_D = (m_D/m_H)^{n/n+2}$. In the special case of harmonic forces, n is 2, and $\nu_H/\nu_D = \sqrt{2}$. In the case of a fourth-power potential field[3], the isotopic ratio ν_H/ν_D should be greater than $\sqrt{2}$ (say, 1·59), whereas it actually is 1,450/1,046 = 1·387.

In view of this controversy the question arises whether the divergence of the vibrational levels is due to a false assignment of combinations and overtones. On the other hand, if this divergence of vibrational levels is real, it could be explained by a quite different mechanism, namely, by assuming that hydrogen fluoride represents an intermediate case between a symmetrical oscillator and an oscillator having a double minimum in the potential function. This implies that the barrier is shallow, and that its height is much lower than the lowest energy-level. The vibrational energy-levels would be split into doublets; the splitting would increase with increasing vibrational quantum number until it would be equal to half the separation of successive unperturbed levels. The divergence of the vibrational levels would be more pronounced the higher the potential barrier.

In view of this possibility, we decided to reanalyse all arguments leading to the assumption of symmetrical hydrogen bonding in hydrogen fluoride.

Proton nuclear magnetic resonance measurements[4] and neutron diffraction[5] showed that the equilibrium position of the proton lay within $\pm$ 0·06 A. and $\pm$ 0·1 A., respectively, of the centre of the ion axis. This does not exclude the possibility of a small and shallow barrier with $2l$ less than 0·12 A.

Pitzer and Westrum proposed a symmetrical structure on the grounds of the absence of a heat capacity peak in the low-temperature region. But as they point out themselves[6], thermodynamic data could not eliminate the possibility of a potential hill so small that the zero energy-level splitting would be greater than 70 cm.$^{-1}$. The possibility of such a splitting was abandoned in view of spectroscopic arguments, which will be discussed later.

Another argument which seemed to favour the symmetrical structure arose from dielectric constant measurements[7]. The dielectric constant of potassium hydrogen fluoride is low (4·1), and is, moreover, nearly independent of temperature. It was suggested that in the case of a double minimum there would be an orientable dipole and a high temperature-dependent dielectric constant would result. However, it can be shown by quantum-mechanical methods that this argument holds only in the case of a large barrier, and thus does not apply to the present case.

Spectroscopic arguments remain. The assignment of the 1,450 cm.$^{-1}$ band as ν_3 and the 1,222 cm.$^{-1}$ as ν_2 is assured[8] and so no doubling of ν_3 is observed. This fact was supposed to eliminate definitely the possibility of a double minimum potential field, but can be explained as follows: if the barrier is very small, then this may be considered as a case intermediate between a double minimum and a symmetrical single minimum oscillator. Calculations show that the zero energy-level splitting might be as large as 1,450 cm.$^{-1}$. The selection rules for a resonance between two $C_{\infty v}$ structures go over into those for a $D_{\infty h}$ structure. The ν_3 band at 1,450 cm.$^{-1}$ can thus be identified with a $v_{0+} \leftrightarrow v_{0-}$ transition. The $3\nu_3$ band at 5,099 cm.$^{-1}$ may be identified with the $v_{0+} \leftrightarrow v_{1-}$ transition, and as the intensity of the $v_{0-} \leftrightarrow v_{1+}$ transition ($2\nu_3 \leftrightarrow 3\nu_3$) is negligibly small owing to the Boltzmann factor, no second double minimum band can be found. The transition $v_{0+} \leftrightarrow v_{1+}$ ($2\nu_3$) would be forbidden by the selection rules.

Hence, except for the explanation of the hypothetical divergence of the vibrational levels, it is a matter of convenience whether we say that the hydrogen bond in potassium hydrogen fluoride is a symmetrical one or that it represents a limiting case of the double minimum type.

I wish to thank Prof. D. Hadži for stimulating and helpful discussions and Prof. A. Peterlin for reading the manuscript critically.

R. Blinc

J. Stefan Institute,
Ljubljana,
Yugoslavia.
July 21.

[1] Cote, G. L., and Thompson, H. W., *Proc. Roy. Soc.*, A, **210**, 206 (1951–52).
[2] Pitzer, K. S., and Westrum, E. F., *J. Chem. Phys.*, **15**, 526 (1947).
[3] Bell, R. P., *Proc. Roy. Soc.*, A, **183**, 328 (1945).
[4] Waugh, J. S., Yost, D. M., and Humphrey, F. B., *J. Phys. Chem.*, **57**, 486 (1953).
[5] Peterson, S. W., and Levy, H. A., *J. Chem. Phys.*, **21**, 704 (1952).
[6] Pitzer, K. S., and Westrum, E. F., *J. Amer. Chem. Soc.*, **71**, 1940 (1949).
[7] Polder, D., *Nature*, **160**, 870 (1947).
[8] Ketelaar, J. A., and Veder, W., *J. Chem. Phys.*, **19**, 654 (1951).

Synthesis and Structure of 2,6-Dihalo-Benzenone-Indophenylacetate and Benzenone-Indo-3′,5′-Dihalo-Phenylacetate

Hitherto only one compound has been isolated after the esterification of dihalo-benzenone-indophenol with acetic anhydride; this compound was assumed to be 2,6-dihalo-benzenone-indophenylacetate[1]:

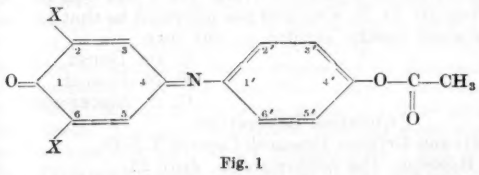


Fig. 1

It is, however, possible to obtain two different acetates—an orange and a red one—from dihalo-benzenone-indophenol, depending on the conditions during the preparation. The two compounds have the same molecular weight and composition, but different colours, melting points, infra-red and ultra-violet spectra and rates of hydrolysis with enzymes.

Red dichloro compound. The red compound was synthesized by a method analogous with Heller's for the preparation of benzenone-indophenylacetate[2]. 5·8 gm. (0·02 mole) of the sodium salt of 2,6-dichlorobenzenone-indophenol in 25 ml. dry ether were heated for 30 min. at 35° C. with 12 gm. acetic anhydride. After cooling, the reaction mixture was put into a beaker containing 500 gm. crushed ice and well stirred for several hours. The ester crystallized; it was filtered off, dried and recrystallized from ether. It formed red crystals, m.p. 99·5°–100·5° C., yield 3·7 gm. (60 per cent), analysis calculated (per cent): C 54·2, H 2·9, N 4·5, Cl 22·9; found: C 54·1, H 2·9, N 4·4, Cl 22·9.

Orange dichloro compound. A modification of a method of Kramer, D. N. (private communication), was used for the preparation of the orange compound. 5·8 gm. (0·02 mole) of the sodium salt of 2,6-dichloro-benzenone-indophenol in 25 ml. dry ether were heated for 15 min. at 35° C. with 2·04 gm. (0·02 mole) acetic anhydride. After cooling, 1 ml. dry pyridine was added. Heating was continued for 15 min. After cooling, the reaction mixture was put in a beaker containing 500 gm. crushed ice and well stirred for several hours. The ester crystallized; it was filtered off, dried and recrystallized from acetone-ether. It formed orange crystals, m.p. 68–69° C., yield 4·3 gm. (70 per cent), analysis calculated (per cent): C 54·2, H 2·9, N 4·5, Cl 22·9; found: C 54·2, H 2·9, N 4·4, Cl 22·9. The corresponding dibromo-compounds were synthesized in the same

Table 1

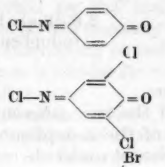
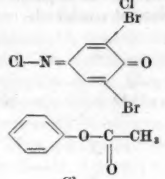
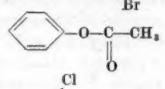
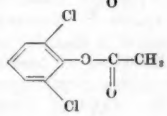
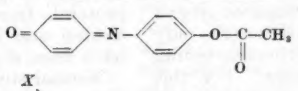
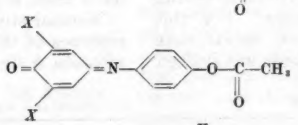
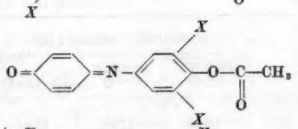
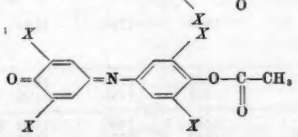
Compound	Wave number (cm.$^{-1}$)		
	Quinonic C=O	Acetoxy C=O	C—O—C
	1637		
	1672		
	1665		
		1765	1190
		1777	1187

Table 2

Compound	Predicted wave number		
	Quinonic C=O	Acetoxy C=O	C—O—C
	*a*	*c*	*e*
	*b*	*c*	*e*
	*a*	*d*	*f*
	*b*	*d*	*f*
	$b > a$ ~1650	$d > c$ ~1750	$f < e$ ~1200

way. Paper chromatography showed that each compound could be obtained free from its isomer.

When, however, methods 1 and 2 are applied in the preparation of 2,6 dihalo-benzenone-indo - 3′ 5′-dihalophenylacetate, identical products are obtained. The same holds for the preparation of benzenone-indophenylacetate.

We assume that the formation of the two different compounds is due to mesomerism of the indophenol ion or to tautomerism of the indophenol molecule :

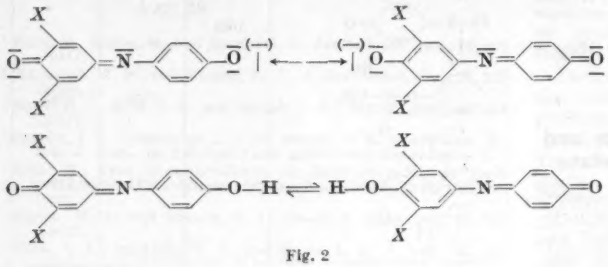
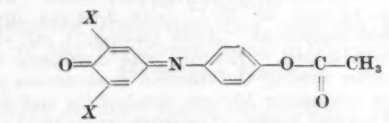


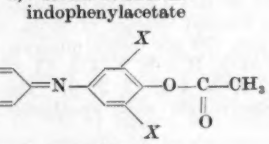
Fig. 2

In that case there are two possibilities for the formation of dihalo esters :



2,6-dihalo-benzenone-indophenylacetate

and

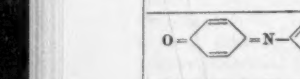


benzenone-indo-3′5′-dihalo-phenylacetate

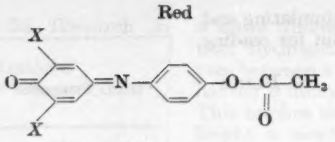
Fig. 3

By studying the infra-red spectra it is possible to determine which of the two structures belongs to the red ester and which to the orange one. Since no groups are characteristic for either of the two structures only frequency shifts due to interactions with surrounding atoms can be taken as a starting point. For this purpose the strong C=O and C—O—C bands were chosen. Generally C=O stretching bands are shifted to higher frequencies when halogen atoms are substituted at a carbon atom next to the C=O group[3]. The influence of halogen atoms in model compounds was studied. The results are shown in Table 1.

Table 3

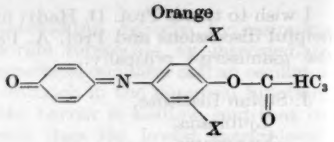
Compound	Observed wave number (cm.$^{-1}$)		
	Quinonic C=O	Acetoxy C=O	C—O—C
	1648	1758	1190
Red dichloro compound	1665	1753	1189
Red dibromo compound	1662	1755	1195
Orange dichloro compound	1648	1768	1182
Orange dibromo compound	1646	1778	1179
Tetrachloro compound	1673	1782	1173
Tetrabromo compound	1668	1770	1166

Red



2,6-dihalo-benzenone-indophenylacetate

Orange



benzenone-indo-3′,5′-dihalo-phenylacetate

Fig. 4

From Table 1 the position of the bands can be predicted for the following compounds.

The results obtained with the infra-red spectra of the compounds under consideration are shown in Table 3.

The most characteristic shift is shown by the quinone C=O band. The other shifts can be considered as giving additional evidence for the assignment. Comparison of experimental results with the predicted values leads to the conclusion that the structure of the red and the orange compound is as shown in Fig. 4.

Note added in proof. While this letter was in the press, Dr. D. N. Kramers has informed us that he has obtained results similar to our own.

C. de Borst
F. N. Hooge
G. J. Arkenbout

Chemical Laboratory,
National Defence Research Council T.N.O.,
Rijswijk, The Netherlands. July 25.

[1] Kramer, D. N., and Gamson, R. M., *Anal. Chem.*, **30**, 251 (1958).
[2] Heller, G., *Chem. Ann.*, **392**, 16 (1912).
[3] Weisberger, A., "Tech. of Org. Chem.", **9**, "Chem. Applications of Spectroscopy" (Interscience Pub., New York, 1956).

Transport of Vitamin A Ester in Rat Serum

It has been established in this laboratory that vitamin A alcohol is associated with the α_1-globulin of rat serum, but not with the low- or high-density lipoproteins and probably also not with the α_1-glycoprotein[1]. In continuation, the absorption of vitamin A alcohol and its transport to the liver as the ester have been studied.

Normal stock rats of the Wistar strain (vitamin A reserves of the liver ± 3,000 I.U./gm.) were put on a vitamin A deficient diet for 48 hr. and were then fed 500 I.U. of vitamin A-2-^{14}C (1·07 mc./mmole) in 0·2 ml. purified peanut oil by stomach tube. Under these conditions no vitamin A ester could be detected in the blood before feeding, but the vitamin A absorbed after administration of the dose should appear in the blood in the esterified form. After administration of the labelled vitamin A, blood samples were collected from the tail at intervals, combusted and counted as barium carbonate in a proportional counter converter (Nuclear Measurements Corporation, type *PCC*-10). The

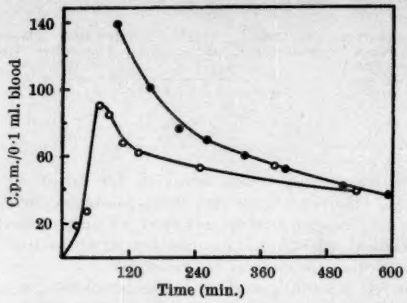


Fig. 1. Appearance of radioactivity in the blood of rats after dose of vitamin A-2-^{14}C (1·07 mc./mmole). ●—●, Rat 1; ○—○, rat 2

radioactivity in the blood reached a maximum after 1½–2 hr. (Fig. 1).

A group of ten stock rats was similarly treated and after 1½ hr. blood was drawn from the dorsal aorta, allowed to clot for 2 hr., and the serum collected and pooled. The lipoproteins were isolated by ultracentrifugal flotation fractionation at solution densities of 1·063 and 1·20 gm./ml. in the Model *E* analytical 'Spinco' ultracentrifuge[2] and directly combusted. The salt concentration of the sedimented proteins was lowered by dialysis and aliquots were afterwards combusted. For vitamin A alcohol and ester estimations, the serum samples were extracted, the alcohol and ester separated by chromatography on alumina[3] and determined by the Carr–Price colour reaction. Samples of the ester and alcohol fraction were also combusted. The carbon dioxide obtained from the combustions was assayed for radioactivity. The results of the analyses are summarized in Tables 1 and 2.

Tables 1 and 2 show that the value obtained by Carr–Price estimation of the vitamin A ester content of serum correlates well with the vitamin A levels, as calculated from radioactivity measurements on either the isolated lipoprotein or vitamin A ester fractions. It further appears that part of the normal serum vitamin A alcohol content of ± 100 I.U./100 ml. was replaced by labelled vitamin A, since the vitamin A alcohol fraction as well as the sedimented proteins, which transport vitamin A alcohol, contained radioactivity.

Table 1. Analysis of Vitamin A Alcohol and Ester Fractions after Extraction from Serum

Description of analysis	I.U./100 ml. serum		
	Ester	Alcohol	Total*
Carr-Price colour reaction after chromatographic separation	127	98†	
Calculated from radioactivity measurements after chromatographic separation	149	27·7	176·7

Table 2. Distribution of Vitamin A between the Protein Fractions obtained by Ultracentrifugal Flotation Fractionation

Description of analysis	I.U./100 ml. serum		
	Lipoprotein fraction	Sedimented proteins	Total*
Calculated from radioactivity measurements on fractions obtained at solution density 1·063 gm./ml.	132·7	38	170·7
Calculated from radioactivity measurements on fractions obtained at solution density 1·20 gm./ml.	130·1	34·6	164·7
Calculated from radioactivity measurements on whole serum			177

* Total refers to labelled ester and alcohol only.
† Consists of both labelled and unlabelled material.

In rat serum, vitamin A ester is therefore transported by the low density lipoproteins. A similar result was recently reported for human plasma[4]. It is interesting to note that the transport of vitamin A ester is similar for man and the rat, despite the species difference.

Mention should be made that the proteins, after extraction of vitamin A ester and alcohol, contained low residual radioactivity. This is probably due to a vitamin A transformation product, since it was found that, on feeding labelled vitamin A to vitamin A deficient rats, the excretion of radioactivity in the urine reached a maximum after 6 hr. and then rapidly decreased (Garbers, C. F., unpublished results).

This communication is published by permission of the South African Council for Scientific and Industrial Research. I thank Prof. J. Gillman, who suggested the vitamin A transportation problem, and Dr. D. A. Sutton for many helpful discussions, Mr. P. C. van Berge for assistance in the ultracentrifugal experiments and Dr. M. Peisach for radioactivity determinations.

C. F. Garbers
Joint Nutrition Unit of the South African Council for Scientific and Industrial Research and the University of the Witwatersrand, Johannesburg,
National Chemical Research Laboratory, South African Council for Scientific and Industrial Research, Pretoria. June 19.

[1] Garbers, C. F., Gillman, J., and Peisach, M., *S. Afr. J. Med. Sci.*, **23**, 34 (1958).
[2] DeLalla, O., and Gofman, J. W., in "Methods of Biochemical Analysis", edit. by Glick, D., **1**, 459 (Interscience Pub., New York, 1958).
[3] Thompson, S. Y., Ganguly, J., and Kon, S. K., *Brit. J. Nutrit.*, **3**, 50 (1949).
[4] Krinsky, N. I., Cornwell, D. G., and Oncley, J. L., *Arch. Biochem. Biophys.*, **73**, 233 (1958).

Effect of Diet on Imidazole Compounds and Creatine in Chinook Salmon

Halver[1,2] has recently devised highly purified diets for the Chinook salmon (*Oncorhynchus tshawytscha*), which have been used to determine the amino-acid and vitamin requirements for this species[2,3]. Since the muscle of the salmon contains both free histidine and anserine[4], it was of interest to determine the content of these imidazole compounds in the muscles of histidine-deficient fish. Samples of these and also of control and methionine-deficient salmon were made available to us through the courtesy of John E. Halver, U.S. Fish and Wildlife Service, Cook, Washington. The weight of the histidine and methionine-deficient fish over a ten-week feeding period was relatively constant at 1·8 gm., whereas the control fish increased in weight from 1·8 to 3·3 gm. The skeletal muscles of four fish in each group were combined and were analysed for histidine, 1-methylhistidine, carnosine and anserine by the ion-exchange method of Davey[4,5], and also for creatine and creatinine by the method of Van Pilsum *et al.*[6]. Non-protein nitrogen was determined by micro-kjeldahl. Results are shown in Table 1.

Although histidine is an essential amino-acid for these fish[2], it is present in the muscle in relatively

Table 1. Effect of Diet on some Skeletal Muscle Constituents of Chinook Salmon

Sample diet	Histidine	1-Methyl-histidine (μmoles/gm. wet tissue)	Carnosine	Anserine	Non-protein nitrogen (mgm./gm.)	Creatine (mgm./gm.)	Creatinine (mgm./gm.)	Imidazole nitrogen in non-protein nitrogen (per cent)
Control	2·7	1·0	3·3	5·7	3·8	4·9	0·59	17·0
Histidine-deficient	0·3	0·4	0·4	6·1	3·0	6·0	0·25	12·8
Methionine-deficient	0·4	0·6	0·7	8·2	4·2	7·1	0·31	14·0

large amounts and, as expected in the histidine-deficient fish, there was a decrease in its concentration. The change in carnosine concentration indicates that just as in the case of rats, in which carnosine can liberate histidine, it can replace histidine in the diet[7]. The depleted histidine and carnosine in fish deficient in methionine suggest the possible importance of histidine as a one-carbon donor in fish. In all cases the concentration of anserine remained essentially constant. Since histidine, either through 1-methylhistidine or carnosine, is probably the sole source of anserine, it is rather surprising that the organism, on a histidine-deficient diet, maintains its anserine concentration at a high level. It appears that no demethylating system is available here, just as in the case of the chick,(Ousterhout, L., Department of Poultry Husbandry, University of California, personal communication), which, on a histidine-deficient diet, maintains a constant anserine level while histidine and carnosine are progressively depleted. The variation in 1-methylhistidine is explained on the basis of anserinase activity, which has previously been suggested to be present in salmon[4] and which has been demonstrated in cod[8].

Choline-deficient fish from a different experiment were also analysed. Although the results cannot be compared directly, the very high creatine concentration of 11·3 mgm./gm. obtained is noteworthy.

A. Lukton

Institute of Marine Resources,
Department of Food Technology,
University of California,
Berkeley 4, Calif.
July 23.

[1] Halver, J. E., *J. Nutrition*, **62**, 245 (1957).
[2] Halver, J. E., *J. Nutrition*, **62**, 225 (1957).
[3] Halver, J. E., DeLong, D. C., and Mertz, E. T., *J. Nutrition*, **63**, 95 (1957).
[4] Lukton, A., and Olcott, H. S., *Food Research* (in the press).
[5] Davey, C. L., *Nature*, **179**, 209 (1957).
[6] Van Pilsum, J. F., Martin, R. P., Kito, E., and Hess, J., *J. Biol. Chem.*, **223**, 225 (1956).
[7] Du Vigneaud, V., Sifferd, R. H., and Irving, G. W., *J. Biol. Chem.*, **117**, 589 (1937).
[8] Jones, N. R., *Biochem. J.*, **60**, 81 (1955).

Replacement of Adrenaline and Noradrenaline in the Innervated and Denervated Adrenal Gland of the Rat, following Depletion with Reserpine

In a previous communication[1] we have shown that reserpine causes a similar percentage loss of adrenaline and noradrenaline from the adrenal gland of the rat. Subsequent recovery of the adrenal amine content was found to be slow. Experiments have now been performed to determine whether this action of reserpine is central or peripheral.

It has been shown by Kroneberg and Schümann[2] that denervation of the adrenal gland of the rat by cutting the spinal cord at the level of *C*6 does not prevent reserpine causing a loss of adrenal catechols. Recently, Mirkin[3] has confirmed this by cutting the splanchnic nerves. However, in both instances the glands have only been assayed for total catechol amines. Here a study has been made of the adrenaline and noradrenaline content of innervated and denervated rat adrenal glands during and subsequent to the depletion caused by reserpine.

The left adrenal glands of male albino rats, weighing 80–100 gm., were denervated by cutting the greater and lesser splanchnic nerve fibres under pentobarbitone sodium anæsthesia—a modification of the method of Vogt[4]. The rats were then left for 3 weeks for the amine content of the glands to return to normal. Test rats were then given 1 mgm./kgm. of reserpine subcutaneously daily for 3 days. Control rats were given the reserpine solvent only. In all experiments test and control groups, each consisting of 10 rats, were killed at 3, 7, 14 and 21 days following the first injection of reserpine, and the adrenal glands removed. The glands were extracted and assayed biologically for adrenaline and noradrenaline, as described earlier[1]. The amine content was expressed in μgm./gland and the points in Fig. 1 represent the percentage difference in amine content between the respective test and control groups.

It can be seen from Fig. 1, derived from the results of three experiments using 300 rats, that there was a similar percentage depletion of adrenaline and noradrenaline, of the order of 40 per cent, in both innervated and denervated glands. The adrenaline then slowly recovered to normal in both groups. However, the noradrenaline content rose to about 200 per cent above the control value at 7 days, falling at 14 days to approximately 80 per cent above, finally returning to normal at 21 days. This occurred in both the innervated and the denervated glands. This similarity between innervated and denervated glands is well seen if the percentages of noradrenaline in the two groups are compared. This is shown at the top of Fig. 1. Before depletion

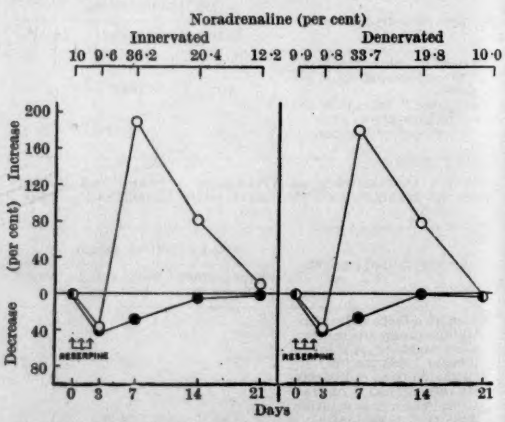


Fig. 1. A composite diagram to show the similarity in the rate of replacement of adrenaline (●) and of noradrenaline (○) in the innervated and denervated adrenal gland of the rat, at various time intervals following depletion with reserpine (1 mgm./kgm.). All results are expressed as percentages of the amine contents of the respective control glands

innervated and denervated glands contain about 10 per cent of noradrenaline. At 3 days, following a similar percentage loss of both adrenaline and noradrenaline, there is still about 10 per cent of noradrenaline present. However, at 7 days both contain about 30 per cent of noradrenaline. This falls to the normal value of 10 per cent by 21 days. Thus no appreciable difference, in either the depletion or replacement of adrenaline and noradrenaline, could be found between innervated and denervated rat adrenal glands. It may be concluded, therefore, that the action of reserpine on the rat adrenal gland is peripheral.

We wish to thank Ciba Laboratories, Ltd., for generous gifts of reserpine.

B. A. Callingham
Monica Mann

Department of Pharmacology,
School of Pharmacy,
29–39 Brunswick Square,
London, W.C.1.
Aug. 6.

[1] Callingham, B. A., and Mann, M., *Nature*, **181**, 423 (1958).
[2] Kroneberg, G., and Schümann, H. J., *Arch. Exp. Path. Pharmak.* **231**, 349 (1957).
[3] Mirkin, B. L., *Nature*, **182**, 113 (1958).
[4] Vogt, M., *J. Physiol.*, **104**, 60 (1945).

Mast Cell and Histamine in Rat Anaphylaxis: the Effect of *Haemophilus pertussis*

It is now well established that mice and rats can be rendered hypersensitive to anaphylaxis by inoculation with *Haemophilus pertussis* vaccine, phase I organisms[1]. Treatment with *H. pertussis* also decreases the resistance of mice and rats to several unrelated factors as well as to histamine[1,2] and serotonin[3]. It is also well known that most of the tissue histamine is located in the mast cells[4] and that in rats and mice these cells are also rich in serotonin[5]. The fact that anaphylaxis in the rat produces mast cell damage and release of histamine into plasma[6] led us to investigate the behaviour of these cells in anaphylaxis of rats treated with *H. pertussis*.

White rats (N.I.M.R. strain) of both sexes and weighing between 200 gm. and 250 gm. were used. Two groups of six animals each were studied. One group was injected with 1 ml. of horse serum subcutaneously and the other received 1 ml. of horse serum by the same route plus 1 ml. of *H. pertussis* vaccine containing 20,000 million organisms intraperitoneally. All the animals were challenged 10 days later by injecting 1 ml. of horse serum intravenously under light ether anæsthesia. 5 min. later, 2 ml. of blood was collected, by puncture of the vena cava, in a syringe containing heparin, and the plasma immediately obtained by centrifugation at 0° C. The animals were then killed by bleeding, and the skin of the snout and lips and the tongue were fixed by injecting through the carotid artery a fixative consisting of 50 per cent aqueous ethanol containing 10 per cent formaldehyde and 5 per cent acetic acid. Fixation was allowed to proceed overnight and frozen sections 50μ thick were stained with toluidine blue. The percentage of mast cells showing granule extrusion was determined by counting 500 cells at a magnification of × 160. The plasma histamine content was assayed on the guinea pig ileum.

The results of these experiments are shown in Table 1. As can be seen, inoculation with *H. pertussis* enhances the sensitivity to anaphylaxis so that mast cell disruption (the term disruption is here used to describe mast cells presenting granules scattered around the cell without implying damage to the cell membrane) and appearance of histamine in plasma resulted after injection of antigen. The mechanism by which *H. pertussis* inoculation leads to increased sensitivity to anaphylaxis is not yet understood. The increased sensitivity to histamine produced by *pertussis* vaccine does not explain the increased sensitivity to anaphylaxis since it has been shown that sensitivity to anaphylaxis is still present at a time when there is absence of histamine hypersensitivity[7]. The same seems to be the case with the increased sensitivity to serotonin[7]. Since the response of rats treated with *H. pertussis* to several noxious agents is very similar to that presented by adrenalectomized rats[8], the hypothesis has been proposed that *H. pertussis* acts in some way by causing damage to the adrenal glands. Nevertheless, all attempts to demonstrate a direct effect of *H. pertussis* on the adrenal glands have so far failed[7,9]. It is our experience, however, that after anaphylaxis the number of disrupted mast cells in adrenalectomized rats is also larger than in non-adrenalectomized rats, and that this effect can be prevented by treatment with cortisone. Neither adrenalectomy nor *pertussis* inoculation seems to enhance antibody production[9,10].

Table 1. Plasma Histamine Concentration (μgm./ml.) and Mast Cell Disruption (per cent) in Anaphylaxis of Rats treated and untreated with *H. pertussis*

Rat	Disrupted mast cells		Histamine	
	Untreated	Treated with *H. pertussis*	Untreated	Treated with *H. pertussis*
1	0	67	< 0·03	1·9
2	0	44	< 0·03	0·8
3	0	70	< 0·03	1·8
4	0	85	< 0·03	2·0
5	0	38	< 0·03	1·6
6	0	32	< 0·03	0·8

A possible explanation for the effect both of adrenalectomy and inoculation with *H. pertussis* would be that the tissue cells are more sensitive to the pharmacologically active materials produced as a consequence of the antigen–antibody reaction. However, the fact that hypersensitivity to anaphylaxis does not necessarily co-exist with hypersensitivity to histamine or serotonin, and our present results showing that *H. pertussis* treatment increases mast cell damage and histamine release in anaphylaxis, suggest that it is the effectiveness of the antigen–antibody reaction in directly causing cell damage that is enhanced. The fact that in rats that have not been treated with *H. pertussis* it is also possible to produce mast cell disruption and release of histamine[6] suggests that the effect of inoculation of *H. pertussis* is not a qualitatively new process. Sensitization by the intraperitoneal route is much more effective in producing mast cell disruption and appearance of histamine in plasma in anaphylaxis than sensitization by the subcutaneous route (for example, in a group of rats sensitized by the intraperitoneal route with alum-precipitated bovine serum albumin the average of disrupted mast cells after shock was 32 per cent, while in a similar group injected by the subcutaneous route only it was 0·4 per cent). This difference does not seem to be due to qualitative or quantitative differences in the antibodies produced, but it may be related to the fact that *H. pertussis* is not effective when

injected subcutaneously[10]. A comparative study of the effectiveness of the several routes of sensitization in promoting mast cell disruption and histamine release into plasma in anaphylaxis is in progress.

I. Mota*

The National Institute for Medical Research,
The Ridgeway,
Mill Hill,
London, N.W.7.

* Fellow of the Rockefeller Foundation. Permanent address: Department of Histology, Faculty of Medicine, University of S. Paulo, Brazil.

[1] Malkiel, S., and Hargis, B. J., *Proc. Soc. Exp. Biol. Med.*, **80**, 122 (1952); **81**, 689 (1952).
[2] Parfentjev, I. A., and Goodline, M. J., *J. Pharm. Exp. Therap.*, **92**, 411 (1948).
[3] Kallós, P., and Kallós, L. D., *Int. Arch. Allergy*, **11**, 237 (1957). Munoz, J., *Proc. Soc. Exp. Biol. Med.*, **95**, 328 (1957).
[4] Riley, J. F., and West, G. B., *J. Physiol.*, **120**, 528 (1953).
[5] Benditt, E. P., Wong, R. L., Arase, M., and Roeper, E., *Proc. Soc. Exp. Biol. Med.*, **90**, 303 (1955). Sjoerdsma, A., Waalkes, T. P., and Weissbach, H., *Science*, **125**, 1202 (1957).
[6] Mota, I., *Brit. J. Pharmacol.*, **12**, 453 (1957).
[7] Munoz, J., Schuchardt, L. F., and Verwey, W. F., *J. Immunol.*, **80**, 77 (1958).
[8] Flashman, D. H., *J. Infect. Dis.*, **38**, 461 (1926). Crivellari, C. A., *Amer. J. Physiol.*, **81**, 414 (1927).
[9] Malkiel, S., *J. Allergy*, **27**, 445 (1956).
[10] Malkiel, S., Hargis, B. J., and Feinberg, S. M., *J. Immunol.*, **71**, 311 (1953).

Release of Ammonia by Plant Tissues treated with Indole-3-Acetic Acid

In a previous investigation[1], the uptake of amino-acids by plant tissues was followed by means of radioisotopic techniques. When colorimetric techniques were employed in their stead it was found that uptake was masked by the movement of ninhydrin-positive substances from the tissue into the external solution. This observation led to a study of the release of these substances by plant segments. It was observed that when segments of etiolated hypocotyls of *Helianthus annuus* were floated in water or a solution of indole-3-acetic acid (the range tested was $1{\cdot}1 \times 10^{-5} - 1{\cdot}1 \times 10^{-4}\ M$) ninhydrin-positive substances rapidly made their appearance in the external medium. The concentration of these substances appeared to reach a maximum value within 2 hr.: continued immersion led to no increase in the ninhydrin colour of the medium but, on the contrary, to its gradual diminution. It was further observed that, while indole-3-acetic acid had no clear-cut influence on the initial loss from the tissue, it had a remarkable effect on the amount of ninhydrin-positive material detectable in the medium after about 20 hr. At this stage the concentration in the media containing the auxin was 2–6 times higher than that in the controls (see Table 1).

The behaviour of the ninhydrin-positive substances did not reflect the permeability of the cell membranes to solutes in general. Flame photometry showed that more potassium had been lost to the surrounding fluid after 20 hr. than after 3 hr., and that the loss was greater in the absence than in the presence of auxin. Similarly, after 20 hr., the aldose and ketose concentrations were if anything somewhat higher in the control media. These findings accorded with the visibly better condition of the auxin-treated segments, which were white and turgid with less tendency to turn brown at the cut ends.

Subsequent investigation by means of filter paper chromatography showed that the ninhydrin-positive material present after 20 hr. and so markedly affected by indole-3-acetic acid was not qualitatively identical with that lost from the tissue during the initial period. That lost initially was found to consist principally of glutamine, asparagine, glutamic acid, aspartic acid, leucine and valine. There is evidence that the disappearance of these substances during the course of the experiment was due not only to uptake by the tissue but also to destruction in the medium by enzymes secreted by the tissue. Indole-3-acetic acid had no appreciable effect on this destruction.

Table 1. The Effect of Indole-3-Acetic Acid on the Amount of Ninhydrin-Positive Material detectable in the Medium surrounding Segments of Sunflower Hypocotyl

Experiment	Indole-3-acetic acid (concentration in μM)	Fresh weight of segments (mgm.) Initial	Fresh weight of segments (mgm.) Final	Ninhydrin-positive material in medium (colorimeter units*)
I. 20 segments in 3 ml. for 18 hr.	0	552	589	15·1
		596	643	18·0
	11	554	703	39·0
		582	760	42·0
II. 110 segments in 15 ml. for 21 hr.	0	3,005	3,315	4·7
		2,985	3,260	2·9
	29	2,816	4,085	22·8
		2,998	4,368	27·9
III. 25 segments in 3 ml. for 16·5 hr. Media buffered at *p*H 5·8 with 0·02 *M* KOH–KH_2PO_4	0	737	838	3·1
		806	866	4·5
	29	743	956	13·0
		808	1,010	12·4

* $2{\cdot}1 \times 10^{-4}\ M$ ammonium sulphate ≡ 1 unit

The ninhydrin-positive material present after 20-hr. incubation with the segments was only detectable on filter paper if the solution had been acidified prior to concentration and application to the paper. The spot then reacted strongly with Nessler reagent as well as with ninhydrin. The solution before concentration had the following properties: (*a*) it gave an immediate yellow colour with Nessler reagent; (*b*) when mixed with potassium carbonate – potassium bicarbonate buffer, *p*H 9·4, and distilled under reduced pressure in a Parnas apparatus under conditions under which glutamine did not break down, it yielded a distillate which was both Nessler- and ninhydrin-positive; (*c*) when mixed with saturated potassium carbonate and distilled in a Conway microdiffusion apparatus for 3 hr. it yielded an alkaline vapour which could be absorbed in borate buffer. It is thus highly probable that the substance under investigation was ammonia (it will be referred to as such below) though this has not been conclusively proved. It might, for example, be an exceedingly labile substance (considerably more labile than glutamine) readily breaking down to give ammonia. The influence of indole-3-acetic acid could be clearly followed by all of the analytical methods listed under (*a*), (*b*) and (*c*) above.

The work so far described was carried out with seedlings of the variety Pole Star which had been grown in the dark at 24° C. for 7 days. Segments 1 cm. long were cut from the hypocotyls at a distance of 1 cm. below the crook and floated in shallow layers of solution contained in large, stoppered flasks which were shaken gently throughout the experiment. When a change was made to a new batch of seeds from a different supplier, difficulty was at first experienced in reproducing the auxin

Table 2. THE EFFECT OF SUCCINATE AND SUCROSE ON THE AUXIN-STIMULATED ACCUMULATION OF AMMONIA IN MEDIA SURROUNDING SEGMENTS OF SUNFLOWER HYPOCOTYL

(20 segments, cut from the hypocotyls of 8-day-old seedlings, were placed in 2 ml. medium for 18 hr. The media were buffered at *p*H 5·9 with 0·02 *M* potassium hydroxide–potassium dihydrogen phosphate)

Additive (concentration in m*M*)	Indole-3-acetic acid (concentration in μM)	Fresh weight of segments (mgm.)		Ninhydrin-positive material in medium (colorimeter units*)
		Initial	Final	
None	0	612	645	6·4
	0	635	664	8·6
	29	621	748	27·7
	29	635	780	22·0
Sodium succinate (4)	0	625	645	4·2
	0	635	656	3·8
	29	619	748	0·6
	29	634	756	1·6
Sucrose (44)	0	623	649	3·3
	0	636	663	4·0
	29	638	763	1·6
	29	638	774	6·3

* $2{\cdot}1 \times 10^{-4}$ *M* ammonium sulphate ≡ 1 unit.

effect. It was then found that the effect was readily demonstrable either if the plants were allowed to grow for a further three days before removal of the segments, or if the segments themselves were 'aged' by continued immersion in the experimental solutions. These observations suggested that the appearance of ammonia might be due to the utilization of amino-acids as a substrate in respiration (cf. Yemm[2]) and that this process only started after some other substrate had been exhausted, which in the case of the new seeds required more time. Attempts were therefore made in further experiments (carried out with the variety Jupiter) to counter the auxin-stimulated production of ammonia by the provision of an alternative respiratory substrate. Table 2 shows that the addition of either succinate or sucrose prevented the accumulation of ammonia in the media containing the auxin.

If ammonia production was in fact reflecting the respiration of amino-acids it is of importance to note that indole-3-acetic acid did not bring about a stimulation in overall respiration-rate comparable in magnitude with that effected in ammonia production. The oxygen uptake of auxin-treated tissue was at no stage of the experiment more than 25 per cent above that of the controls. The stimulation in ammonia production, on the other hand, was of the order of 200 per cent. This would indicate that in the auxin-treated tissue amino-acids formed a larger proportion of the substrate respired, and may imply a connexion between the action of auxin and the respiration of amino-acids. This suggestion was made previously[3] on entirely different grounds, namely, the higher specific activity of the carbon dioxide evolved by auxin-treated, as compared with control, segments when radioactive glutamic acid was supplied in the external solution. Another possible explanation for the higher proportion of amino-acids apparently respired in the presence of indole-3-acetic acid is that the increased cell-wall synthesis stimulated by the auxin consumes alternative respiratory substrates such as sugars.

The disappearance of the auxin effect in the presence of succinic acid or sucrose does not necessarily indicate, however, that these substances were suppressing the oxidation of amino-acids. They may have provided acceptor molecules for the ammonia produced in processes other than oxidation. It is possible, for example, that the release of ammonia observed in media containing auxin was connected, not with respiration, but with protein synthesis. A preliminary to the latter might be the hydrolysis of glutamine and asparagine, considerable reserves of which are known to be present in this tissue.

The effect of indole-3-acetic acid reported here is not confined to sunflower tissue. It has also been noted in the epicotyls of *Pisum sativum* var. Alaska, though the effect has not yet been investigated further in this case.

This work will be published in detail elsewhere.

I wish to express my appreciation of the encouragement given me by Prof. G. E. Blackman, director of this Unit.

LEONORA REINHOLD

Agricultural Research Council
Unit of Experimental Agronomy,
Department of Agriculture,
University of Oxford.

[1] Reinhold, L., and Powell, R. G., *J. Exp. Bot.*, **9**, 82 (1958).
[2] Yemm, E. W., *Proc. Roy. Soc.*, B, **123**, 243 (1937).
[3] Reinhold, L., and Powell, R. G., *Nature*, **177**, 658 (1956).

Presence in Root Tips of a Thermolabile Factor causing the Conversion of Protochlorophyll to a Leuco-Compound

IN a previous paper[1], it was reported that protochlorophyll occurs in the tips of dark-grown roots. It was also shown that protochlorophyll disappears immediately after living root tips have been squashed. It also disappears from raw ether extracts during the evaporation of the ether. This implies that neither the pulp from squashed tips nor the watery residue dissolved in ether exhibits any red fluorescence. I have now succeeded in demonstrating that some thermolabile factor is responsible for this destruction of protochlorophyll.

To prepare an extract containing this factor, about 5 gm. of fresh root tips (apical part of root, about 0·5 cm. in length) from seedlings grown in 'Vermiculite' moistened with the nutrient solution were ground with sand in a mortar with 20 ml. of ether. The ether solution was decanted and used as a source of the factor. To activate this factor, however, it was necessary to remove the ether from the extract. Extracts from root tips of both *Zea mays* and *Helianthus annus* were tested.

The protochlorophyll was prepared as a raw extract from dark-grown wheat leaves according to Virgin[2], but in some series the leaves were first killed by immersion in water at 100° C. for 10 min. The following procedure was then used to determine the activity of the factor. 1 ml. of the extract from the root tips was put into an Erlenmeyer flask together with two drops of distilled water, and the ether was removed by evaporation *in vacuo*. The concentrated aqueous extract was kept for 10 min. at temperatures of 20° C. or at 100° C. (water-bath). 4 ml. of the protochlorophyll extract were then added and the ether removed. As a second evaporation increased the effect of the factor, 4 ml. of the ether were added to the aqueous residue after 2 min. at 20° C. and the ether was again removed. The extract was then diluted with 4 ml. of ether and its absorption in red light was determined spectrophotometrically by means of a Beckman spectrophotometer model *DU*. The fluorescence was estimated visually[1].

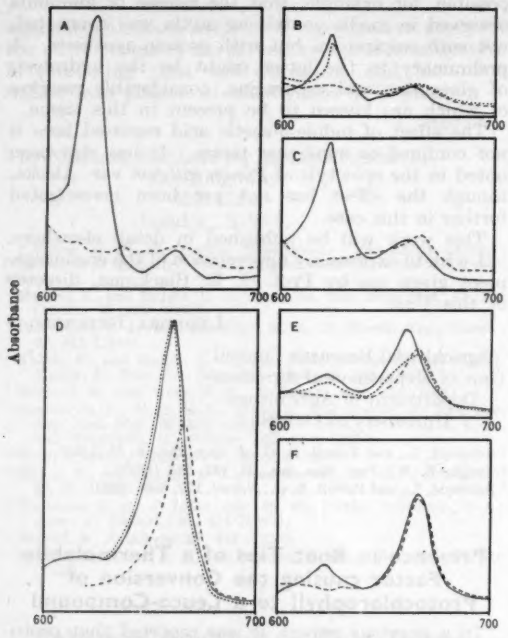


Fig. 1. Absorption of the different samples. ——, Initial absorption of the sample; ....., absorption after evaporation procedure without active factor; – – – –, absorption after test proc dure with the active factor from root tips of *Zea* (*A*,*F*) and of *Helianthus* (*B*,*C*,*D*,*E*). *A*,*B*,*C*, samples containing protochlorophyll together with very small amounts of chlorophyll *a* (contamination due to imperfect green light during extraction). *D*,*E*, extracts containing chlorophyll *a* resulting from light transformation of protochlorophyll. Small amounts of non-transformed protochlorophyll present in *E* (crude extract) but not in *D* (purified extract). *F*, solution of purified pheophytin *a* in a mixture with raw extract of protochlorophyll

The results (Table 1, Fig. 1) indicate the following: the root-tip extract contains a factor which causes decomposition of protochlorophyll into a compound without red light absorption. When protochlorophyll was the only red fluorescing substance in the solution (without chlorophyll), the red fluorescence disappeared completely. This indicates that the product of decomposition is not protopheophytin, since if this were the case the solution ought to give a distinct red fluorescence[3]. The activity of the factor is destroyed by heating. The susceptibility to heating indicates that it may be associated with a protein (an enzyme ?).

Table 1. Absorption of the Test Solutions at the Point of Maximum of Red Absorption of Protochlorophyll (623 mμ). The red fluorescence determined visually according to the method earlier described (ref. 1) is given below the figures for the absorption. The values are the means from three determinations

Sample	Initially	Ether removed by evaporation and new ether added		
		Without root tip extract	Root tip extract added: at 20° C.	Root tip extract added: heated to 100° C. for 10 min.
Protochlorophyll from dark-grown wheat leaves. Root tip extract from *Zea mays*	0·013 strong	0·012 strong	0·005 none	0·013 strong
Protochlorophyll from dark-grown wheat leaves (also containing small amounts of chlorophyll *a*) (cf. Fig. 1*B*). Root tip extract from *Helianthus*	0·320 strong	0·032 strong	0·013 weak	0·033 strong
As above, but leaves were killed with hot water before extraction	0·012 strong	0·012 strong	0·005 none	0·013 strong

To determine whether this compound also acts on chlorophyll, etiolated leaves, before extraction, were illuminated for 10 min. with daylight in order to transform part of the protochlorophyll to chlorophyll *a*. It was found, however, that the evaporation of the ether from the raw extract resulted in a conversion of chlorophyll *a* into pheophytin *a*, independently of the presence of the factor in question (Fig. 1*B*). Chlorophyll purified on a saccharose column and dissolved in ether was unchanged during the evaporation of the ether. It was transformed to pheophytin, however, when a small amount of the extract from the root tips was added to the solution even when the extract had been previously heated (Fig. 1*D*). This means that the transformation of chlorophyll *a* into pheophytin *a* is not dependent on the factor in question but is rather due to some acidic impurities present in the extract.

To determine whether the factor exerts any effect on pheophytin *a*, pure pheophytin in ether solution alone and combined with a raw protochlorophyll extract were tested with the same procedure as used for protochlorophyll. One example is given in Fig. 1*F*. It can be seen that the factor has no influence on pheophytin.

The protochlorophyll in raw extract from etiolated wheat leaves mixed with an ether extract from root tips is fairly stable so long as the ether is not removed by evaporation. Since the evaporation of the ether from the extract resulted in an increase of the concentration of water, one may assume that the increased water content is responsible for the activation of the factor. The method of extraction of root tips with ether was employed only for its convenience in the test procedure. The factor probably dissolves in ether along with water and other substances, but to be active it requires a higher concentration of water than is present in the non-evaporated ether extract. The factor is not stable in the ether extract. Its activity disappears after two to three weeks at 0° C.

Z. Hejnowicz

Institute of Plant Physiology,
Lund. July 30.

[1] Hejnowicz, Z., *Physiol. Plant.*, 11, 878 (1958).
[2] Virgin, H. I., *Physiol. Plant.*, 11, 347 (1958).
[3] French, C. S., Smith, J. H. C., Virgin, H. I., and Airth, R. L., *Plan Physiol.*, 31, 369 (1956).

An Observed 'Oxygen Effect' during Gamma-irradiation of Dried Bacterial Spores

On numerous occasions it has been shown that changes produced in aqueous biological systems by exposure to ionizing radiations of low specific ionization can be influenced by environmental conditions during irradiation. Since it is considered that environmental conditions affect the types and yields of free radicals formed on irradiation of water, the suggestion has been made that the observed biological changes are induced mainly by indirect action. Recent observations on irradiated non-aqueous synthetic macromolecular systems and on dry isolated cellular constituents have shown that changes produced by direct action can also be influenced by environmental

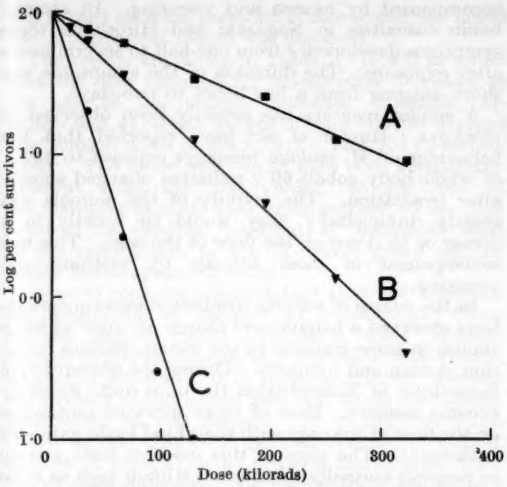


Fig. 1. γ-Irradiation of *B. subtilis* spores in kaolin powders sealed under reduced pressure and under air. *A*, secondary dried powder under reduced pressure; *B*, primary dried powder under air; *C*, secondary dried powder under air

conditions[1-3]. Alexander[4] has therefore postulated that direct action may cause changes in biological systems in cases where, in the past, it was thought that indirect action was responsible. However, alteration of the environmental conditions in circumstances where only direct action is known to be operative has not yet been shown to influence the lethal action of ionizing radiations on bacterial cells.

During a series of experiments involving γ-irradiation of spores of *Bacillus subtilis*, which had been dried in atmospheres of low aqueous vapour pressure, it has been observed that the presence of oxygen during irradiation influences their survival.

A powder, known to contain *B. subtilis* spores evenly distributed throughout it, was prepared by spray-drying a mixed aqueous suspension of kaolin and spores[5]. This is referred to as a primary dried powder. Glass tubes containing samples of known weights of this primary dried powder were attached to a glass manifold which in turn was connected to a two-stage rotary vacuum pump via a refrigerated moisture trap. Using this apparatus, the samples of primary dried kaolin powder were further dried for 6 hr. at a pressure of 0·001 mm. of mercury with liquid nitrogen as refrigerant. The powder dried in this way is referred to as a secondary dried powder. At the end of the secondary drying period, some of the samples of powder were sealed under reduced pressure (0·001 mm. of mercury) while others were sealed under air which had first passed through the moisture trap. Dose/log per cent survivor curves obtained from the γ-irradiation of spores in secondary dried kaolin powder sealed under reduced pressure and sealed under air, and the curve obtained from the irradiation of spores in primary dried powder sealed under air, are given in Fig. 1. The criterion of survival adopted was the ability of spores to produce colonies when sown into nutrient agar medium.

The low free-water content of bacterial spores[6,7] and the extreme drying conditions to which they are subjected during secondary drying probably ensure that killing of the spores on γ-irradiation occurs as a result of direct action. A comparison of curves *A* and *C* shows that the presence of air during irradiation greatly increases the kill of spores in secondary dried kaolin powder. This finding indicates that the observation of an 'oxygen effect' during irradiation of bacterial cells cannot be taken as evidence that indirect mechanisms are operative.

Comparison of curves *B* and *C* shows that spores in secondary dried kaolin powder, irradiated in the presence of air, are more sensitive to γ-radiation than spores in primary dried kaolin powder irradiated in the presence of air. This finding is of particular interest since the observed inverse relationship between moisture content and radiosensitivity is contrary to what would be expected from a consideration of the more usually reported protective effect resulting from dehydration of living cells. Further results from this series of experiments will be published elsewhere.

ALAN TALLENTIRE

Department of Pharmacy,
The University,
Manchester, 13.
July 9.

[1] Alexander, P., *Rad. Res.*, **6**, 653 (1957).
[2] Alexander, P., and Charlesby, A., *Nature*, **173**, 578 (1954).
[3] Pollard, E., Powell, W. F., and Reaume, S. H., *Proc. U.S. Nat. Acad. Sci.*, **38**, 173 (1952).
[4] Alexander, P., "Advances in Radiobiology" (Oliver and Boyd, Edinburgh, 1957).
[5] Bullock, K., and Tallentire, A., *J. Pharm. Pharmacol.*, **4**, 917 (1952).
[6] Powell, J. F., and Strange, R. E., *Biochem. J.*, **54**, 205 (1953).
[7] Ross, K. F. A., and Billing, E., *J. Gen. Microbiol.*, **16**, 418 (1957).

Absence of Pectolytic Enzymes in a Pathogenic Strain of *Fusarium oxysporum f. lycopersici*

THE pectic enzymes produced by *Fusarium oxysporum* Schl. emend. Sny. and Han. f. *lycopersici* (Sacc.) Sny. and Han. have been considered to play an important part in the production of symptoms and of wilting in tomato plants infected with *Fusarium*[1]. It has been suggested that pectic enzymes are not responsible for the full range of symptoms[2,3] and that other metabolites may be involved. The pectic enzymes have also been considered important for the invasion of a wide range of plants by fungal parasites[3].

During the course of an investigation of the pectic enzymes of *Fusarium oxysporum* f. *lycopersici* an attempt was made to produce mutants which lacked pectic enzymes. The mutants were obtained by subjecting microconidia of strain *R*–5–6 (obtained from Prof. J. C. Walker, Wisconsin) to ultra-violet irradiation and a subsequent screening procedure. The usual method for isolating biochemically deficient mutants was reversed, the irradiated conidia being first plated out on a minimal medium (glucose–minerals) to eliminate any nutritionally deficient mutants. The colonies, arising from single microconidia, which developed on the minimal medium were screened over plates of pectin (B.D.H. 'Apple Pectin' Grade 240) agar and of pectate (sodium polypectate, California Fruit Growers Exchange) gel[4], and those which obviously differed in rate of growth from the wild type were selected for further study. The pectin and sodium polypectate used in the preparation of the screening media contained traces of glucose which facilitated at least limited growth of all survivors. A number of mutants were thus selected and their abilities to produce pectic enzymes and their pathogenicities were investigated under standard conditions.

The pectic enzyme activities of pectin–agar plate cultures and of liquid culture filtrates were estimated by modifications of the cup-plate assay method[5]. It was during these investigations that mutant strain 80, which produced no pectolytic enzyme, but which produced pectin methyl esterase, was found. This was afterwards confirmed using the Willstäter–Schudel hypoiodite method for polygalacturonase and the viscometric method for depolymerase.

Strain 80 was moderately pathogenic in the susceptible tomato variety Kondine Red either when seedlings were root inoculated or when cuttings were inoculated by the transpirational method[6]. The symptoms produced included petiole epinasty, some leaf yellowing and shrivelling, vascular browning, and vascular plugging. However, symptoms of more severe disease, such as severe wilting and collapse of the leaves and death of the plant, as might be seen in those plants inoculated with the wild type, *R*–5–6, were never apparent. The pathogenicity measurements were made with batches of twenty plants inoculated with each strain, under conditions which were optimal for disease development.

It is possible that the mutation (in strain 80) is one leading to a requirement for some specific substance for pectolytic enzyme synthesis and that this substance is available to some extent in the host tissues. If this is not the case, it can be concluded that pectolytic enzyme production is not necessary for the successful establishment of *F. oxysporum*. f. *lycopersici* in the host plant and that the pectolytic enzymes play no part in the production of symptoms in moderately diseased plants.

This work, the full details of which will be published elsewhere, has been carried out during the tenure of an Agricultural Research Council Research Studentship. I am indebted to Dr. N. F. Robertson under whose supervision the investigations were made.

K. McDonnell*

Botany School,
Downing Street,
Cambridge. July 17.

* Present address: Glaxo Laboratories, Ltd., Fermentation Research Division, Sefton Park, Stoke Poges, Bucks.

[1] Pierson, C. F., Gothoskar, S. S., Walker, J. C., and Stahmann, M. A., *Phytopathology*, **45**, 524 (1955).
[2] Wood, R. K. S., 5th Symp. Soc. Gen. Microbiol., Cambridge (1955).
[3] Brian, P. W., 5th Symp. Soc. Gen. Microbiol., Cambridge (1955).
[4] Wieringa, K. T., Rep. Proc. 4th International Congress for Microbiology, Copenhagen (1947).
[5] Aschan, K., and Norkrans, B., *Physiol. Plant.*, **6**, 564 (1953). Dingle, J., Reid, W. W., and Solomons, G. L., *J. Sci. Fd. Agric.*, **4**, 149 (1953).
[6] Keyworth, W. G., *Nature*, **166**, 955 (1950).

Initial Irradiation Reaction in Mice

Exposure of the whole body to large doses of ionizing radiations produces an immediate effect in primates. In man the absorption of 500 r. of X-rays or γ-rays causes a sensation of lassitude, often accompanied by nausea and vomiting. In atomic-bomb casualties in Nagasaki and Hiroshima these symptoms developed[1,2] from one-half to several hours after exposure. The duration of the symptoms was short, ranging from a few hours to two days.

A similar reaction has recently been observed in monkeys. Hunter *et al.*[3] have reported that the behaviour of *M. mulatta* monkeys exposed to 450 r. of whole body cobalt-60 γ-radiation changed shortly after irradiation. The activity of the animals was greatly diminished; they would sit quietly in a corner or lie down on the floor of the cage. This was accompanied in most animals by retching and vomiting.

In the course of various irradiation experiments we have observed a behavioural change in mice which is similar in some respects to the initial reaction occurring in man and monkeys. During the absorption of large doses of X-irradiation the mice quite suddenly became inactive. Most of them sprawled motionless on the floor of the cage with their hind limbs extended backwards. The mice in this inactive state seemed to respond normally to external stimuli such as noise and painful pressure on their tails. The duration of inactivity lasted from 5 to 30 min. after exposure.

We have termed the amount of total body irradiation which is required to bring about inactivation in mice, the 'inactivation dose'. In the present study we measured the inactivation dose in a number of mice to determine with what degree of constancy the phenomenon occurred; we also irradiated mice of different age groups to determine whether age had any effect on inactivation.

Forty-seven adult male white mice (Connaught Laboratory strain) were arranged in three age groups, namely, 2, 3½ and 4½ months. No animal received more than the amount of irradiation required to produce inactivation. All animals were observed for 30 days, and the deaths which occurred were recorded. A Ferranti (*RV*–220) therapy unit was used. The radiation factors were as follows: operating voltage, 200 kV.; tube current, 20 m.amp.; H.V.L., 1·55 mm. of copper. The animals were irradiated at a distance of 40 cm., which produced a dose rate in air of 48 r./min. In order to determine the time of inactivation with more accuracy than by visual observation, the following simple movement-recording device was used. The mouse was placed in a small wire cage which rested on a wooden platform under the X-ray beam. The platform was supported by four light coil springs, one in each corner. A piezo-electric crystal (recording cartridge) was attached to the side of the platform by its stylus and allowed to hang freely. In this manner the movements of the platform, made by the mouse, were transmitted to the crystal in which piezo-electric currents were produced. These electrical impulses were amplified and recorded on an ink-writing recorder (Varian Associates, Palo Alto, California). The X-ray unit

Table 1. The Range and Average Values of the Inactivation Dose in Mice of Different Age Groups

	No. of animals	Average weight of animals (gm.)	Inactivation dose (r.)		*P*	No. of deaths	Mortality (per cent)
			Range	Av. S.E.			
2-month old mice	20	21·3	400–800	604±26		11	55
3½-month old mice	20	27·6	375–725	512±23	0·02	7	35
4½-month old mice	7	34·4	400–650	503±32	0·05	0	0

was turned off when cessation of movement was noted and a permanent record was obtained.

The results are shown in Table 1. It will be noted that the dose required for inactivation decreases as the age of the animal increases. 2-month, 3½-month and 4½-month groups of mice showed average inactivation doses of 604 r., 512 r. and 503 r., respectively. The latter two values were both statistically different from the first value. 55 per cent of the youngest animals died when exposed to the dose required to produce inactivation, compared with 35 per cent deaths in the 3½-month group and no deaths in the 4½-month group.

There is considerable evidence[4] that age decreases the sensitivity of animals to irradiation. Older animals require more irradiation than younger animals to produce comparable degrees of leukopœnia, anæmia or lethality. It is, however, evident that the inactivation phenomenon does not follow the dosage relationship in this manner. If it did, we would expect to find that older animals required a greater amount of irradiation to produce inactivation than the younger animals. Our results show the reverse to be true, which suggests that the nature of inactivation is different from the other manifestations of irradiation injury.

This work was supported by the National Cancer Institute of Canada.

HAROLD BLONDAL
Department of Physiology and Medical Research,
Faculty of Medicine,
University of Manitoba,
Winnipeg.
July 21.

[1] Medical Research Council, "The Hazards to Man of Nuclear and Allied Radiations" (H.M. Stationery Office, London, 1956).
[2] Oughterson, A. W., and Warren, S., "Medical Effects of the Atomic Bomb in Japan", National Nuclear Energy Series 8 (McGraw-Hill Book Co., Inc., 1956).
[3] Hunter, C. G., Munson, R. J., Court Brown, W. M., and Abbott, J. D., *Nature*, **180**, 1466 (1957).
[4] Cronkite, E. P., and Brecher, G., *Ann. Rev. Med.*, **3**, 193 (1952). Lamerton, L. F., and Baxter, C. F., *Brit. J. Radiol.*, **28**, 87 (1955).

Corneo-Fundal Potential Variations during Light and Dark Adaptation

THE corneo-fundal potential (that is, the steady potential difference across the eye) was discovered in 1849 by Du Bois-Reymond[1]. Noell[2] has recently shown evidence that a part of the corneo-fundal potential is attributable to the membrane polarization of the pigment epithelium adjacent to the sensory cells of the retina. He found, while measuring the retinogram in rabbits, polarization changes lasting for more than 200 sec. following the onset of illumination. An analogous phenomenon, described in detail below, occurs in humans.

The surface-potential differences obtained from electrodes placed on the skin near the eyes (outer canthi) were shown by Mowrer, Ruch and Miller[3], in animals, to be related to the electrical polarization (cornea positive with respect to fundus) of the eye-bulb.

A method of surface-recording similar to that used by Miles[4] for studies of individual differences in humans was modified by Kris[5], giving the results described here.

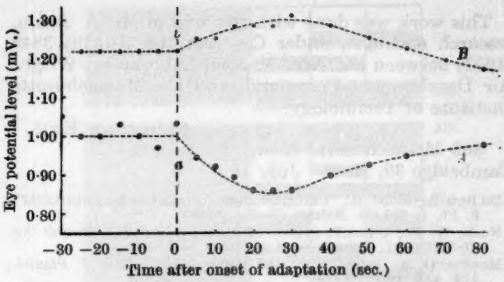


Fig. 1. Curves of variation of eye potential-level changes at onset of (○ – – ○) light adaptation, and (● – – ●) dark adaptation. *a*, Light on; *b*, light off. Measurements taken from left eye *D–C* horizontal record of subject *SS*, sections 1_1 and 1_{14}

When the eye has been adapted either to light or dark, a step-change in illumination produces an initial transient effect lasting between 60 and 80 sec., as shown in Fig. 1.

For light-adaptation, the initial transient dip (curve *A*) is followed by a fluctuation resembling a damped oscillation of 30 min. period, lasting approximately one hour (Fig. 2). The peak and trough times observed in 18 complete light-adaptations by six subjects fell within the following ranges: 1st peak at 10th min. ± 2 min.; 1st trough at 25th min. ± 4 min.; 2nd peak at 36th min. ± 4 min. These variations include the diurnal variations of three subjects who were adapted repeatedly over a 30 hr. test-period[6]. One subject, who did not show initial transients, reported red-green colour-blindness. While the pattern of fluctuation was the same for light-adaptations to illumination intensities of 7 and 140 millilamberts, the amplitude of fluctuation was higher with the higher level of illumination (Fig. 2, *a* and *c*).

For dark-adaptation following complete light-adaptation, the initial transient rise (Fig. 1, curve *B*) is followed by a fall in potential-level over the first 8–10 min., and then by a gradual rise (taking approximately 20 min.) to a steady-state level which is regularly somewhat lower than that of the light-adapted steady-state level. See Fig. 2, section *b*, which shows the first 20 min. of a dark-adaptation curve.

The presence of a damped oscillation suggests a homœostatic mechanism.

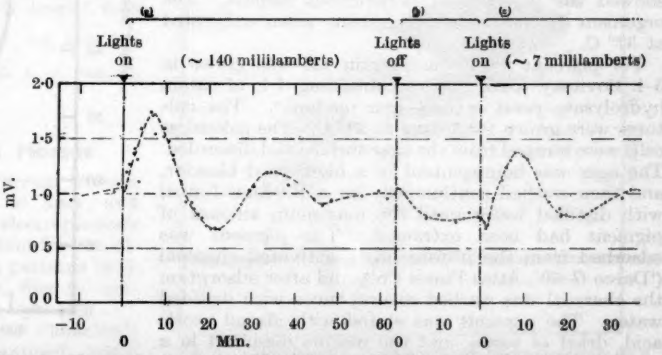


Fig. 2. Changes in eye potential-level during adaptation successively to (*a*) strong illumination; (*b*) darkness; (*c*) moderate illumination. Subject: *RS*. Ordinates: change in potential across electrode-pair lateral and mesial to left eye, produced by standard 60° horizontal fixation shifts

This work was done with the help of Mr. A. Atkin, research assistant, under Contract *AF* 33(616)–3849 (1957) between the Aero-Medical Laboratory, Wright Air Development Command, and the Massachusetts Institute of Technology.

Christine Kris

863 Massachusetts Ave.,
Cambridge 39, Mass. July 16.

[1] Du Bois-Reymond, E., "Untersuchungen über thierische Elektrizität", 2, Pt. 1, 256 (G. Reimer, Berlin, 1849).
[2] Noell, W. K., U.S.A.F. School of Aviation Medicine, Project No. 21-1201-0004, Report No. 1 (October 1953).
[3] Mowrer, O. H., Ruch, T. C., and Miller, N. E., *Amer. J. Physiol.*, **114**, 423 (1936).
[4] Miles, W. R., *Proc. U.S. Nat. Acad. Sci.*, **25**, 128 (1939).
[5] Kris, C., Aero-Medical Laboratory, Wright Air Development Command, Contract *AF* 33(616)-3849, Final Technical Report (July 1957).
[6] Kris, C., Soc. Proc., Eastern Assoc., *J. EEG Clin. Neurophysiol.*, **9**, 382 (1957).

A Water-soluble, Diffusible Pigment produced by a Strain of *Serratia marcescens* (*Chromobacterium prodigiosum*)

Members of the bacterial species, *Serratia marcescens*, are characterized by the production of red or pink pigments. These pigments are described as being insoluble, or sparingly soluble in water, and to be associated with the bacterial cell[1,2]. Heavily pigmented strains show some diffusion of pigment into agar media, but the organisms still retain most of the colour[2,3]. We wish to report a red-to-pink pigment produced by a strain of *S. marcescens* which not only is readily soluble in water, but which also diffuses from the organisms into the medium and leaves the cells colourless.

S. marcescens strain 125 was received from Dr. L. S. McClung of the Department of Bacteriology, Indiana University, Bloomington. The strain had been identified as *S. marcescens* by Hamilton[4]. Tests carried out in our laboratory demonstrated that the organism was a small, motile, cocco-bacillary, Gram-negative rod. It fermented glucose, mannitol, and sucrose without the production of gas. Lactose and maltose were not fermented. The citrate and nitrate tests were positive, but those for hydrogen sulphide production, indole, and urease were negative. Gelatin was liquefied. With the exception of the failure to ferment maltose, these characteristics are those of *S. marcescens* organisms as presented in authoritative sources[1,2,4,5]. Electron microscopy showed the presence of peritrichous flagella. The organism did not produce pigment when cultivated at 37° C.

For pigment production, strain 125 was grown in 5-l. Povitsky toxin bottles containing 1 l. of casein hydrolysate–yeast extract–agar medium[6]. The cultures were grown for 5 days at 27° C. The colourless cells were scraped from the agar surface and discarded. The agar was homogenized in a high-speed blendor, and then washed continuously on a Buchner funnel with distilled water until the maximum amount of pigment had been extracted. The pigment was adsorbed from the filtrate on to activated charcoal ('Darco *G*–60', Atlas Power Co.), and after adsorption the charcoal was washed several times with distilled water. The pigment was eluted with glacial acetic acid, dried *in vacuo*, and the residue dissolved in a small amount of distilled water. Since the pigment is insoluble in petroleum ether this solvent was used for washing the water solution several times to remove contaminating substances. Final purification of the pigment was effected by continuous paper electrophoresis in 5 per cent acetic acid on a 'Spinco' Model *CP* unit. The pigment moved as a single band, and all of it was collected in only two tubes. Acetic acid was removed from the eluate by drying *in vacuo*, and washing the dried material several times with petroleum ether. The pigment was then dissolved in a small amount of distilled water, lyophilized, and stored as the dry substance.

The purified pigment was red to pink in colour, and was insoluble in acetone, chloroform, ether and petroleum ether, but was soluble in ethanol, methanol, and water. In solvent systems composed of lutidine and water (5 : 3), and *iso*propanol, concentrated hydrochloric acid and water (65 : 16·6 : 18·4) the pigment moved as a single band. The bands showed no fluorescence under short or long wave-length ultra-violet light. Paper electrophoresis demonstrated that the pigment moved as a single substance in barbiturate buffer, *p*H 8·6, as well as in acetic acid. The isoelectric point in acetate buffer was *p*H 3·5. After combustion of material eluted from chromatograms, there still remained considerable ash. Therefore chemical analysis of the pigment must await more complete purification. Efforts to crystallize the pigment have thus far failed. The acid, base and neutral spectra of the pigment are presented in Fig. 1. The spectral maxima are at 550 and 280 mμ, and the minimum is at 425 mμ. These values do not vary with changes in *p*H, although the shape of the curves is somewhat modified.

To our knowledge this is the first time a water-soluble, diffusible pigment of *S. marcescens* has been

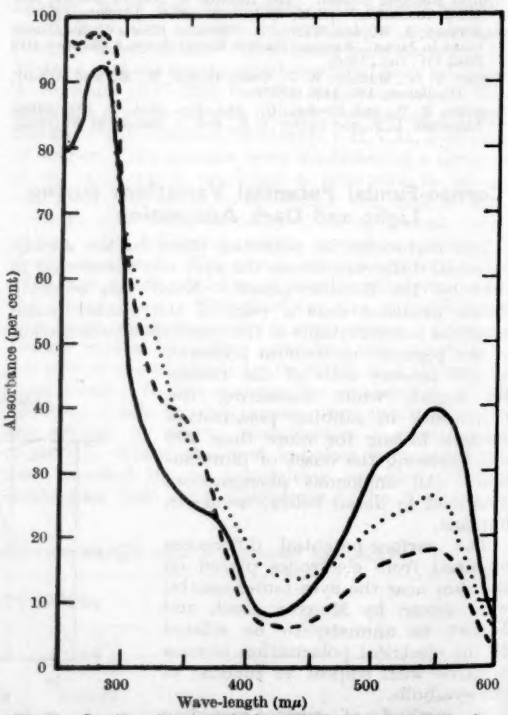


Fig. 1. Spectra of water-soluble, diffusible pigment from *S. marcescens*. – – – in acid, *p*H 4; . . . in alkali, *p*H 9; —— in neutral solution. All spectral determinations were carried out in water solutions

reported. The biochemical tests establish the fact that strain 125 is *S. marcescens*, and the presence of peritrichous flagella, as well as the fermentation reactions, indicate that the organism cannot belong to the pseudomonad group. It has been pointed out that *Serratia* organisms can vary widely in their ability to produce pigment, and in the colour of the pigment[1,2]. Thus it should not be surprising to find that certain strains produce a diffusible, rather than a cellular, pigment.

It is of interest to compare certain properties of extracted cellular pigment with those of diffusible pigment. In contrast to the latter substance, cellular pigment is insoluble in water, but readily soluble in acetone, chloroform, ether and petroleum ether[6]. It cannot be moved by paper electrophoresis. Both pigments are red in colour, but the diffusible pigment is of a lighter shade. The spectrum of the cellular pigment shows marked shifts with variation in *p*H, and the maximum peaks in acid solution are at 540, 375 and 275 mμ, and the minima, at 420 and 330 mμ[6]. As can be seen in Fig. 1, the spectrum of diffusible pigment shows little variation with changes in *p*H, and although the acid curve has maxima and minima similar to those of cellular pigment, the two spectra are not identical. Cellular pigment also can be separated into several fractions[6], whereas diffusible pigment appears to be a single substance. Thus with respect to the above characteristics, there are marked differences between cellular and diffusible pigment. Whether there are any relationships in chemical structure between the two pigments must await further investigations.

This investigation was supported in part by research grant *E*–670(C3), and in part by a Medical Student Summer Research Fellowship to one of us (W. W. T.), both from the National Institutes of Health, U.S. Public Health Service.

R. P. Williams
W. W. Taylor
D. Hawkins, Jr.
I. L. Roth

Department of Microbiology,
Baylor University College of Medicine,
Houston 25, Texas.

Aug. 5.

[1] Wilson, G. S., and Miles, A. A., "Topley and Wilson's Principles of Bacteriology and Immunity", 4th edition, 730 (Williams and Wilkins, Baltimore, 1955).

[2] Breed, R. S., Murray, E. G. D., and Smith, N. R., "Bergey's Manual of Determinative Bacteriology", 7th edition, 360 (Williams and Wilkins, Baltimore, 1957).

[3] Hefferan, M., *Cent. Bakteriol. Parasitenk.*, IIte Abt., 11, 456 (1904).

[4] Hamilton, R. D., "A Critical Study of the Genus *Serratia*", thesis (Indiana University, U.S.A., 1957).

[5] Davis, B. R., Ewing, W. H., and Reavis, R. W., *Int. Bull. Bact. Nomen. and Taxon.*, 7, 151 (1957).

[6] Williams, R. P., Green, J. A., and Rappoport, D. A., *J. Bact.*, 71, 115 (1956).

Serum Protein Variations in Horses

It is now clear that intraspecific serum protein variation is widespread in mammals at least, and that the technique of starch-gel electrophoresis developed by Smithies[1] is a powerful tool for revealing these differences. Complex protein patterns have been obtained with sera from horses, due to concomitant variation in several protein systems.

Sera from 79 thoroughbred and other ('knacker') horses of unspecified breed were examined, using *p*H 7·6 phosphate buffer and electrolyte as described previously[2]. Four variable systems were found,

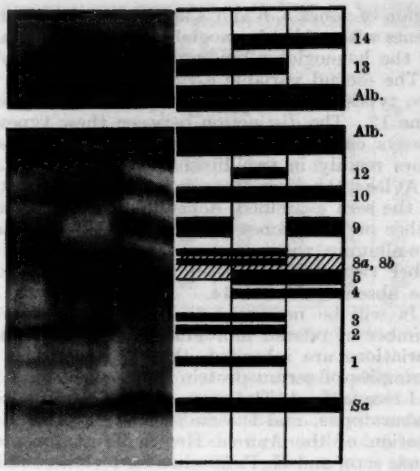


Fig. 1. Starch gel electrophoresis protein patterns from three representative horse sera. Only the anodic side of the gel is illustrated. The main part of the gel was from a 5-hr. run at 200 V.; the pre-albumin portion was from a separate 3-hr. run at the same voltage. Alb., albumin; *Sa*, slow-alpha globulins; 1–6, β-globulins; 8*a*, 8*b* and 9, first variable α-globulins; 12, second variable α-globulin; 13 and 14, pre-albumins. Zone 7 (cross-hatched) is usually rather diffuse and occurs in the region of zones 5, 6 and 8

namely, the β-globulins, pre-albumins and two apparently unrelated α-globulin systems. Electropherograms of three sera illustrating these variations are shown in Fig. 1. A diagram of a two-dimensional agar/starch-gel electropherogram[3] of another serum is shown in Fig. 2.

Three β-globulin types were observed. It is possible that these represent the homozygotes and heterozygote of two β-globulin alleles, one producing zones 1, 2 and 3 and the other zones 4, 5 and 6. This would be comparable with previously described β-globulin systems in other species[3].

Three types have been found in the first of the variable α-globulin systems depending on the presence of either or both zones 8 and 9. In some gels zone 8 is resolved into two zones, 8*a* and 8*b*, but neither of these has so far been found alone. The α-globulin zone 7 is apparently always present but is not sharply defined. In one-dimensional runs it appears in the

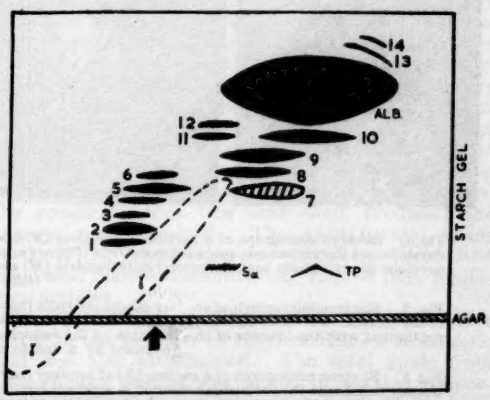


Fig. 2. Diagram of a two-dimensional electropherogram of a selected horse serum. The arrow indicates the position of insertion of the original sample in the agar. γ, γ-globulins; *TP*, thread protein. See also key to Fig. 1

region of zones 5, 6 and 8 as a diffuse band. Experiments with added hæmoglobin suggest that this may be the hæmoglobin-binding protein (haptoglobin).

The second variable α-globulin system has shown two types depending on the presence or absence of zone 12. The distinction between these types is not always easy in one-dimensional runs, but is made more readily in two-dimensional separations.

At least three pre-albumin types have been observed in the sera examined, depending on the presence of either or both zones 13 and 14. However, a third pre-albumin zone, intermediate in mobility to the other two, has been seen in two sera, but only in the absence of zone 14.

It will be necessary to examine an appropriate number of related individuals to determine if these variations are inherited, that is, constitute further examples of serum protein polymorphism.

I thank Mr. A. Thomson, of the Wellcome Research Laboratories, and the staff of the Equine Research Station of the Animal Health Trust for providing horse sera, and K. F. Mitchell for technical assistance.

G. C. Ashton*

The Animal Health Trust,
Farm Livestock Research Centre,
Lilystone Hall,
Stock, Essex. July 25.

* Present address: Sheep Biology Laboratory, P.O. Box 144, Parramatta, N.S.W., Australia.

[1] Smithies, O., *Biochem. J.*, **61**, 629 (1955).
[2] Ashton, G. C., *Nature*, **180**, 917 (1957).
[3] Ashton, G. C., and McDougall, E. I., *Nature*, [182, 945 (1958)].

Fine Structure of the Nuclear Envelope of Carcinoma Cells

Palade[1] was the first to observe with the electron microscope that the plasma membrane forms invaginations which occasionally plunge deeply into the cell body. He has shown that the lumen of the infoldings of the cell membrane communicates with the interior of the endoplasmic reticulum. Watson[2] showed that in certain cells the outer nuclear membrane is continuous with the membrane system of Palade's reticulum. Therefore, his 'perinuclear space' is part and parcel of the cavities of the endoplasmic reticulum. By demonstrating that the inner and outer nuclear membranes fuse at the edges of the nuclear pore, Watson[2] suggested that the nuclear envelope is simply a specialized form of endoplasmic reticulum.

Those considerations about the continuity of the lumen of the endoplasmic reticulum and the perinuclear cisterna are based on electron micrographs of acinar cells of the pancreas, of parenchymatous liver cells and phagocytes and of Rous tumour cells[3]. It was suggested that a relation exists between the magnitude of such structures and the type of activity of the cell under consideration.

During morphological work on cells of chemically induced carcinoma of the cervix uteri of mice, electron micrographs were obtained in which structural details of the nuclear envelope were found to be strikingly similar to those mentioned above. The existence of a double nuclear membrane is shown in Figs. 1 and 3. In some of the carcinoma cells (Fig. 2) the outer nuclear membrane appears to be lifted up and continuous with the endoplasmic reticulum. Moreover, the portion of the endoplasmic reticulum with a rough surface is highly developed and the cytoplasmic matrix of this cancer cell is reduced to narrow strands lying between the swollen cavities of the reticular system (Fig. 2).

Many of the malignant cells show several nuclear indentations, a fact sufficiently known from light microscopy. The electron microscope clearly shows that both the outer and inner nuclear membranes participate to the formation of true nuclear infoldings

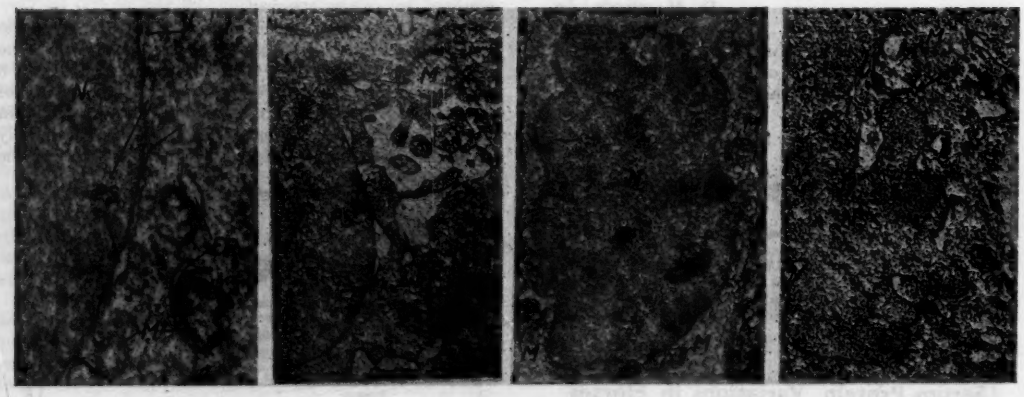


Fig. 1. Electron micrograph of a portion of a nucleus (*N*) and adjoining cytoplasm of a cancer cell. The two layers of the nuclear envelope and the perinuclear space between them (*PS*) are apparent. Nuclear pores are indicated by the arrows. Near the nuclear envelope the cytoplasm contains several mitochondria (*M*) and profiles of rough-surfaced membranes of the endoplasmic reticulum (*ER*). (× 38,000)

Fig. 2. Electron micrograph of another cancer cell from the same tissue as Fig. 1. The granular nucleus (*N*) occupies the left part of the picture. The outer nuclear membrane is reflected into the cytoplasm in such a way that the perinuclear space (*PS*) is clearly continuous with the interior of the labyrinth of the endoplasmic reticulum (*ER*). At the upper left corner another nucleus also bounded by a double nuclear membrane. (× 29,500)

Fig. 3. Electron micrograph of a nucleus (*N*) of another cancer cell from the same tissue as Figs. 1 and 2. Between the double nuclear membrane the perinuclear cisterna is apparent (arrows). A great number of mitochondria (*M*) are closely associated with the depressions of the nuclear envelope. (× 20,000)

Fig. 4. Electron micrograph of a part of another cancer cell of the same tissue as Figs. 1, 2 and 3. The granular nucleus (*N*) shows several deep indentations (arrows). At *PS* the perinuclear space is seen between the inner and the outer nuclear membrane. A mitochondrion (*M*) lies as if waiting for the contents of the indentation. (× 32,000)

(Fig. 4). While the perinuclear space contained within the infoldings may be small, at other sites it is very large (Fig. 4). In addition, it is in direct contact with an important part of the nuclear surface and builds close connexions with deep-seated nuclear areas.

Palade[4] and others suggest that the mechanism of plasma membrane flow may play an important part in securing active transport of substances in both directions through the cytoplasm. Palade[4] has also shown that such cytoplasmic membranes are topographically often closely associated with mitochondria. Fig. 3 shows the nucleus of a cancer cell bounded by an undulating nuclear envelope: within the depressions mitochondria can be seen, closely associated with the nuclear membranes. Fig. 4 illustrates several deep indentations; at the opening of one of them lies a very large mitochondrion.

These nuclear membrane invaginations in cells with active protein synthesis suggest the existence of a mechanism of nuclear membrane flow compensating for increased metabolic exchanges between nucleus and cytoplasm.

M. De Groodt
F. Derom
A. Lagasse
M. Sebruyns
M. Thiery

Institute of Histology,
Laboratory of Electron Microscopy
and Gynæcological Department of the
Cancer Centre,
State University of Ghent.
July 25.

[1] Palade, G. E., *J. Biophys. Biochem. Cytol.*, **1**, 69 (1955).
[2] Watson, M. L., *J. Biophys. Biochem. Cytol.*, **1**, 257 (1955).
[3] Epstein, M. A., *J. Biophys. Biochem. Cytol.*, **3**, 851 (1957).
[4] Palade, G. E., *J. Biophys. Biochem. Cytol.*, **2**, 4 Supp. 85 (1956).

Phosphatidyl Serine and Blood Coagulation

An important aspect of blood coagulation research is the chemical definition of the reacting substances and a question of current interest is the composition of platelet thromboplastic factor.

Previous reports[1,2] have described the clotting activity of brain lipid fractions containing phosphatidyl serine and phosphatidyl ethanolamine; the former inhibited thromboplastin formation while the latter showed acceleratory activity like that of platelet suspensions. Coagulation inhibitory activity has been ascribed to phosphatidyl serine extracted from brain[3,4]. However, Troup and Reed[5] have reported that both phosphatidyl serine and phosphatidyl ethanolamine isolated from platelets potentiated thromboplastin formation, the former compound being the more active. Biggs and Bidwell[6] were unable to associate platelet-like activity of brain phospholipids with any one substance; all were found to be acceleratory. Rapport[7] stated that a brain phosphatidyl serine preparation accelerated coagulation and that this was enhanced by lecithin. Rouser, White and Schloredt[8] found that acceleratory activity was confined to the phosphatidyl ethanolamine component of the platelet lipids.

We have now found that phosphatidyl serine can act as an accelerator (like platelets) or as an inhibitor (as previously reported) of thromboplastin formation, depending on the experimental conditions. Thromboplastin formation was inhibited when the phosphatidyl serine in aqueous solution was placed in the reaction mixture. However, when the phosphatidyl serine was first suspended in aluminium hydroxide adsorbed ethylenediamine tetraacetic acid plasma and then added to the reaction mixture, thromboplastin formation was enhanced. This potentiating effect was not found when citrated or oxalated plasma was employed.

Table 1. Thromboplastin Formation as affected by variously prepared Materials with and without Phosphatidyl Serine
The figures in the body of the table express clotting time of the substrate in seconds

Test material		Incubation time (min.) 2	4	6	8	10
	Buffered saline	60	43	30	26	25
	Platelets	26	10	9	9	10
P.S. 2 mgm./ml. in	EDTA plasma	75	14·5	10·5	10	10
	Citrated plasma	96	66	55	54	50
	Oxalated plasma	100	75	57	52	46
	0·005*M* EDTA	112	103	89	89	85
	Buffered saline	116	105	100	80	77
	EDTA plasma	90	56	43	34	33
	Citrated plasma	82	44	27	23	26
	Oxalated plasma	81	45	37	35	30
	0·005*M* EDTA	92	64	48	42	36

P.S., phosphatidyl serine; EDTA, ethylenediamine tetraacetic acid.

The phosphatidyl serine was prepared from pork brain and on paper chromatography (method of Marinetti and Stotz[9]) consisted of phosphatidyl serine with traces of the lyso compound. Thromboplastin formation was measured by the Biggs–Douglas test[10]. Plasma poor in platelets was separated from normal human blood collected into 1/10 volume of each of the following anticoagulants: 0·027 *M* ethylenediamine tetraacetic acid (the disodium salt of ethylenediamine tetraacetic acid), 0·1 *M* sodium oxalate, and 0·13 *M* trisodium citrate. These plasma were then treated with aluminium hydroxide to remove prothrombin and related factors. The one-stage prothrombin time (with brain thromboplastin) of the adsorbed ethylenediamine tetraacetic acid plasma was greater than 10 min. The phosphatidyl serine was suspended in each of the three plasmas, in buffered saline, and in 0·005 *M* ethylenediamine tetraacetic acid, to a concentration of 2 mgm./ml. Each suspension (0·2 ml.) was substituted for platelets in the Biggs–Douglas test.

The results are shown in Table 1. The buffered saline suspension of phosphatidyl serine was clearly inhibitory. (As previously reported[3], inhibition was also found in the presence of platelets.) However, the phosphatidyl serine in ethylenediamine tetraacetic acid plasma simulated the acceleratory activity of platelets; this activity was maximal at 0·5 mgm./ml. On the other hand, the phosphatidyl serine in oxalated or citrated plasma was somewhat inhibitory or inert. To investigate the activating effect of ethylenediamine tetraacetic acid plasma, the possibility that this acid alone produced the change was examined. The phosphatidyl serine in 0·005 *M* ethylenediamine tetraacetic acid (the calculated plasma concentration) showed only inhibitory activity.

The possibility of some interaction with other lipids[7] in the presence of ethylenediamine tetraacetic acid was also investigated. The total lipids from platelet-poor plasma was mixed in varying proportions with the phosphatidyl serine in 0·005 *M* ethylenediamine tetraacetic acid. Under these conditions only inhibitory activity was found. This result does

not exclude the possibility of lipid interactions under other conditions.

Our phosphatidyl serine preparation (in buffered saline) at appropriate concentrations also accelerated the coagulation of citrated plasma by Russell viper venom ('Stypven' of Burroughs Wellcome) although at higher concentrations venom activity was depressed.

We have detected both phosphatidyl serine and phosphatidyl ethanolamine (as well as other lipids) in normal human platelets by paper chromatography. This finding is in agreement with that of Troup and Reed.

These observations may help to resolve some of the apparently conflicting reports referred to earlier. They also show that the activity of a substance (at constant concentration) may be reversed, thus emphasizing the importance of the particular assay conditions. This work will be reported in greater detail elsewhere.

P. Barkhan
M. J. Silver
P. B. da Costa
L. M. Tocantins

Cardeza Foundation,
Jefferson Medical College,
Philadelphia.
Aug. 5.

[1] Barkhan, P., Newlands, M. J., and Wild, F., *Lancet*, ii, 234 (1956).
[2] Flute, P. T., Barkhan, P., and Rhodes, D. N., Communication to the Sixth Congress of the European Society of Hæmatology, Copenhagen (August 1957). Book of Abstracts, p. 126.
[3] Turner, D. L., and Silver, M. J., *Fed Proc.*, **15**, 189 (1956).
[4] Silver, M. J., Turner, D. L., Holburn, R. R., Schwartz, I. R., and Tocantins, L. M., *Fed. Proc.*, **16**, 249 (1957).
[5] Troup, S. B., and Reed, C. F., *J. Clin. Invest.*, **37**, 937 (1958).
[6] Biggs, R., and Bidwell, E., *Brit. J. Hæmat.*, **3**, 387 (1957).
[7] Rapport, M. M., *Nature*, **178**, 591 (1956).
[8] Rouser, G., White, S. G., and Schloredt, D., *Biochim. Biophys. Acta*, **28**, 71 (1958).
[9] Marinetti, G. V., and Stotz, M., *Biochim. Biophys. Acta*, **21**, 168 (1958).
[10] Biggs, R., and Douglas, A. S., *J. Clin. Path.*, **6**, 23 (1953).

Standard Atmospheres in Respiratory Physiology

Pugh[1], observing on Everest pressures "higher than those calculated according to the standard altimeter calibration" with differences physiologically important above 18,000 ft., rejects the International Commission for Air Navigation (ICAN) 'atmosphere', preferring the temporarily more convenient formula of Zuntz *et al.*[2]. This formula promises to achieve a mystical superiority in high-altitude physiology[3].

The International Commission for Air Navigation 'atmosphere', an approximate world mean atmosphere convenient for altimeter calibrations, is, like any other calculated from simplified formulæ, inaccurate when surface pressure or vertical temperature distribution differs from 'standard'. To correct an altimeter reading accurately, whatever model atmosphere its basis, the complete vertical distribution of virtual temperature below the observer must be known. Assumed 'mean temperatures' will only by chance be satisfactory, particularly if temperature inversions exist below.

Haldane and Priestley[4] and Miss Fitzgerald[5] did not "indicate that the (Zuntz) formula is a better guide to barometric pressure in mountains than the accepted formula for calibrating altimeters" (Pugh, ref. 1). They were clear that the success of any simple formula which does less than fully integrate the weight of air below the observer depends on locality and season. It is unfortunate, therefore, to imply that the Zuntz formula somehow fits "conditions in mountains rather than free air", taking no account of time and place. On a similar mountain in high latitudes, actual pressures would have been lower than those of the International Commission for Air Navigation atmosphere.

Fig. 1 shows the mean departures from the International Commission's 'atmosphere' of the actual seasonal mean pressures measured at three representative latitudes along meridian 80° W. (from data published in a different form[6]). These curves are idealized. Secular variation, continental, oceanic and local topographical climatic influences scatter individual observations considerably, but the pattern is clear: at low latitudes, mean pressures exceed those of the International Commission 'atmosphere', increasing with height to about 10 per cent excess at 40,000 ft., whereas at high latitudes in winter the situation is reversed.

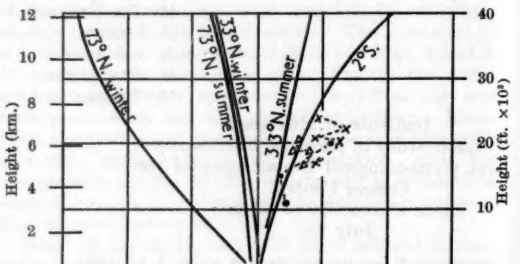


Fig. 1. Seasonal mean pressure deviations from the International Commission for Air Navigation pressures as a function of height, latitude and season. Δp, Excess pressure at each height as a percentage of the International Commission pressure; ●, Pugh (1952) Cho Oyu; △, Williams (1956) Karakoram; ×, Pugh (1953) Everest

Hess's values are fairly representative; the range in height of the mean January and July 300 mb. pressure-levels computed by Bannon[7] confirm these results, as do those of Wexler[8].

Given the local air temperature, differences between the International Commission's heights and those in the real atmosphere at which a given pressure is reached may be computed. Thus, in low latitudes, the International Commission's pressure for 40,000 ft. is usually attained at 42,000 ft. and at high latitudes in winter it is already reached at 37,000 ft.

Since even 'standard' atmospheres display secular drift[9], it may be preferable in high-altitude physiology to think first in terms of pressure, preferably directly measured, relegating altitude *per se* into its evident secondary role.

A final comment may avoid confusion. Pugh, discussing pulmonary ventilation, states that "normal variability of resting ventilation . . . is such that one would not expect to see any close relationship with relatively small changes in altitude, particularly at higher altitudes where change of barometric pressure with height is considerably less than at sea level". This poor correlation is probably entirely due to biological variability. At these altitudes, the fractional pressure change with height, which is the

relevant factor, is in fact more rapid than lower down.

R. H. Kay

University Laboratory of Physiology,
Oxford. Aug. 15.

[1] Pugh, L. G. C. E., *J. Physiol.*, **135**, 590 (1957).
[2] Zuntz, N., *et al.*, "Hohenklima und Bergwanderungen" (Berlin, 1906).
[3] Otis, A. B., "Respiration", in "Ann. Rev. Physiol." (1958). Williams, E. S., *Nature*, **181**, 1527 (1958).
[4] Haldane, J. S., and Priestley, J. G., "Respiration" (Clarendon Press, Oxford, 1935).
[5] Fitzgerald, M. P., *Phil. Trans.*, B, **203**, 351 (1913).
[6] Hess, S. L., *Amer. J. Meteor.*, **5**, 293 (1948).
[7] Bannon, J. K., Toronto Meteor. Conf. Proc., 109 (Royal Meteorological Society, London, 1954).
[8] List, R. J., "Meteorological Data", **2**, 128, and **2**, 129, Amer. Inst. Phys. Handbook (McGraw-Hill, 1957).

The Enigmatical Trematode "*Dictyocotyle coeliaca*"

Dictyocotyle coeliaca Nybelin, 1941, the only monogenetic trematode ever to be found in the cœlom of a vertebrate, was described from two specimens, one from *Raia lintea* near Skagen and the other from *R. radiata* at Trondheim. Ten years ago one of us described two other specimens from *R. clavata* and expressed the hope that a look-out would be kept for the trematode in zoological laboratories[1]. This appeal brought nine specimens from J. E. N. Sloan, formerly of the Zoology Department, University of Edinburgh, and it seems to have led to the publication of two original papers. In neither paper was the total number of parasites specified, but 16 out of 55 *Raia naevus* and 31 out of 73 *R. radiata* taken on Scottish fishing grounds[2] and 35 out of 135 *R. naevus* landed at Plymouth[3] were infected. Mean numbers of parasites per fish were 7 and 4 respectively, and in each instance rays of other species did not yield any parasites. This trematode closely resembles the common cloacal parasite *Calicotyle kroyeri*, differing chiefly in the nature of the posterior adhesive organ (opisthaptor), which is a delicate hookless disk showing faint markings or irregular shapes and sizes. These simulate but are not suctorial compartments, or loculi, such as are found in *Calicotyle* and other Monocotylidae, and mainly for this reason the taxonomic status of *Dictyocotyle* remains undetermined. Llewellyn and Green[3] believe it "distinctly possible" that the host landed at Brixham "had been mis-identified". When at the time confirmation was sought, Dr. E. B. Francis was emphatic, stating, "the species of *Raia* (as mentioned in my previous letter !) was '*clavata*', source Brixham" (letter dated March 26, 1947).

With the finding of new specimens, the senior author recognized the possible validity of the species, though not of the genus[1]. This brought from Dr. H. A. Baylis the comment (*in litt.*, May 3, 1948): "I cannot help feeling sorry that you have now given your blessing to what I am quite sure is a fictitious species. In your book 'The Trematoda' you said, 'in any case it seems safe to assume . . . that *Dictyocotyle coeliaca* is an abnormal form of a species of *Calicotyle*, probably *C. kroyeri*'. With that view I entirely agree, and still agree, having seen the specimens found at Cambridge, to which you refer". However, the authors of the two papers mentioned[2,3] have accepted both genus and species as valid. Such a taxonomic tangle would be a small matter were it not for the extraordinary nature of the trematode concerned. This and the appeal for new specimens

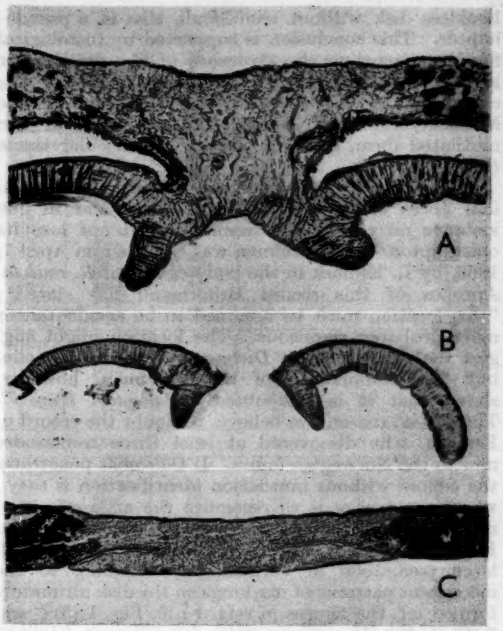


Fig. 1. Transverse sections, dorsal side above, ventral side below. (*A*) *Calicotyle*, showing part of the body (above) and two loculi of the haptorial disk plus the central boss (below). (*B*) discarded opisthaptor of *Calicotyle*, two of the peripheral loculi indicated, boss missing. (*C*) '*Dictyocotyle*', showing the delicate disk without loculi (below) which, it is suggested, is regenerated from the boss of a mutilated specimen

has induced the junior author to examine over a period of five years *Raia radiata* obtained from Plymouth, with the result that 38 additional specimens have been found. Of these, 27 were taken from the anterior part of the liver, 3 from the vicinity of the kidneys, and 7 from the body cavity quite near the openings of the abdominal canals. The canals themselves were dissected consistently and one trematode was actually found inside one of them. Evidently, it had been preserved in the act of passing from the cloaca into the body cavity, and the longitudinally folded condition of the body indicated that passage had not been easy. Moreover, this specimen had lost the opisthaptor, the stalk and adjacent tissue remaining as a kind of button or boss. The missing haptor was not found in this instance, but six isolated opisthaptors were recovered from the cloaca in other instances, along with a total of 317 entire specimens of *Calicotyle kroyeri*. These adhesive organs had evidently been torn from the body of the trematode, each of them having a central perforation which matches the boss of the mutilated specimen (Fig. 1*B*). The boss thus seems to correspond to the stalk plus the torn-out central portion of the opisthaptor (cf. Fig. 1*A*). It was observed also that such mutilation can be induced artificially, presumably because of a line of weakness between the central and peripheral portions of the opisthaptor.

Because of these findings we give it as our considered opinion that *Dictyocotyle coeliaca* is simply a cœlomic form of *Calicotyle* which has entered the body cavity via one of the abdominal pores, which has lost the normal opisthaptor, and which has afterwards modified the central boss by regeneration in such a manner as to produce a delicate

hookless disk without true loculi, that is, a pseudohaptor. This conclusion is supported by histological findings regarding the structure of the opisthaptor in the cœlomic form, which shows none of the characters of the normal adhesive organ of the Monocotylidae and which, like the boss of the mutilated form, shows a paucity of muscular tissue (Fig. 1*C*).

That *Calicotyle* may penetrate the slit-like abdominal pores of certain rays is certain, and in one instance on record the trematode did not lose its opisthaptor. This specimen was collected on April 7, 1868, by L. Esmark in the body cavity of *R. radiata*. Apropos of this record Brinkmann has stated[4]; "this location must be assumed to be accidental, or more probably erroneous. The location might suggest the parasite to be *Dictyocotyle coeliaca* Nybelin, but the examination of this specimen, however, shows that it is undoubtedly *Calicotyle kroyeri*". There is no reason, we believe, to doubt the record of Esmark, who discovered at least three trematodes new to the Norwegian fauna. If *Calicotyle* penetrates the cœlom without mutilation identification is easy; what is not easy is to recognize the after-effects of mutilation, or of existence in a wrong location. Regeneration seems to modify the boss of the mutilated trematode in various ways, leading to the inconstant patterns of markings on the disk ultimately formed (cf. the figures in refs. 1; 2, Fig. 1 (5); and 3, Pl. 1, Fig. 1).

We believe that Baylis was not very wide of the mark when he wrote regarding the damaged haptor (*loc. cit.*): "When torn away from the cloaca, the worm sometimes leaves behind the ventral half of its opisthaptor, still no doubt firmly attached. The dorsal half of this organ shows a reticular pattern due to the presence of a complicated system of muscle fibres which radiate like rosettes from a number of centres, and it is this reticulation which produces the appearance of a large number of loculi, as I have demonstrated by re-staining the Cambridge specimens". (These specimens, we might add, are the ones which Brinkmann identified as *Dictyocotyle coeliaca*, not in 1952 as Llewellyn and Green indicated, but in 1943, that is about five years before Baylis re-examined them.) We doubt the loss of the ventral half of the haptor, however, and suggest that it is the regenerating boss of the mutilated haptor which develops a reticular pattern, for such a reason as Baylis gave. The problem requires further investigation and is being investigated. We would suggest to others interested in the problem that what is required is information on the incidence of both cloacal *and* cœlomic forms where these co-exist, and particularly of the factors which influence the transition. It would be useful also to study the reasons for the failure of the cloacal forms to penetrate into the body cavity of certain species of *Raia* which harbour species of *Calicotyle*.

Ben Dawes

Department of Zoology,
King's College,
London, W.C.2.

Ivor Griffiths

Department of Zoology,
Birkbeck College,
London, W.C.1. Aug. 6.

[1] Dawes, B., *Nature*, **161**, 642 (1948).
[2] Hunter, G. C., and Kille, R. A., *J. Helminth.*, **24**, 15 (1950).
[3] Llewellyn, J., and Green, J., *J. Mar. Biol. Assoc. U.K.*, **36**, 77 (1957).
[4] Brinkmann, A., Univ. Bergen Arb. naturv. R., No. 1 (1952).

Tubule Formation in Rat Brains by Monkey Kidney Cells previously grown *in vitro*

The brain has been employed in this laboratory as a site for the transplantation of malignant cells from tissue culture to rat[1], and such transplantations are proving useful for both oncological and virological investigations. On the assumption that this procedure may also provide a new approach for the study of the nature and mechanism of alterations occurring in cells grown *in vitro* it was decided to apply the procedure to normal monkey cells grown in tissue culture.

Primary cultures of *M. rhesus* kidney were harvested from bottles by means of trypsin (0·06 per cent), centrifuged at 100*g* and resuspended in an amount of diluting material so as to yield approximately 15 million cells per ml. The diluting materials were either the growth medium used for *in vitro* cultivation of cells (solution 199 plus 5 per cent calf serum) or the supernatant fluid from a crude extract of tumour tissue (usually rat-passaged tumour derived from Hep 3 carcinoma). The suspended cells were injected intracerebrally (0·1 ml.) into young Wistar rats which had previously received X-radiation (320 r.) and cortisone (two injections of 3–5 mgm. each). At several intervals the animals were killed and the brain removed for histological examination. The results showed that not only did monkey renal cells survive and perhaps multiply in the rat brain, but also that these cells actually assembled in groups giving rise to tubular structure. One could find epithelial-like cells in nests, aggregates and tubular arrangements in various parts of the brain. The tubular structures were especially prominent, in several instances, in the meninges of the sulci. This is shown in Fig. 1. At first it was thought that tubule formation was more pronounced following the exposure of the cells to tumour extract. Subsequent experiments did not reveal such an 'inducing' capacity in the extracts.

Thus, cells derived from adult kidneys, dissociated from their original organization, cultivated in an undifferentiated monolayer *in vitro* appeared com-

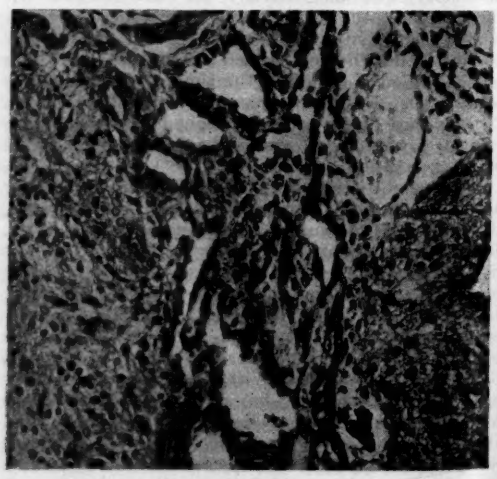


Fig. 1. Brain seven days following injection of trypsinized monkey kidney cells in tissue culture. There are numerous epithelial tubules in the meninges of a cerebral sulcus. Hæmatoxylin and eosin stain. (× 160)

petent to reconstruct the structure of their origin. Is this ability resident in adult kidney epithelium? According to Oliver *et al.*[2], nephron reconstitution as contrasted with epithelial cell regeneration in damaged kidney requires the presence of an intact basement membrane. An experiment testing this point has not yet been done. It remains to be determined whether the sojourn of the cells in tissue culture plays a part in evoking this phenomenon. The relationship of the phenomenon to kidney tubule formation from dissociated chick embryo nephroblasts[3] *in vitro* or to the development of tubules and glomeruli in rat brain implanted with metanephrogenic rudiments and metanephrogenic mesenchyme recently reported by Grobstein and Parker[4] is as yet not known. Nor is it known from the work done thus far whether the brain plays a part as an organizer or inducer in tubule formation. Be it as it may, the present findings attest further to the utility of the brain as a transplantation site—a fact well documented by workers[5–8] using malignant or embryonic tissues.

We are grateful to Dr. Albert M. McCallen, chief radiologist, and to Mr. Mack Holcomb, therapy technician, of the Veterans Administration Hospital at Coral Gables, for providing equipment and assistance for irradiation of the animals.

This work was supported in part by project No. *NR* 103–371 of the Office of Naval Research and by grant No. *E*–1526 of the National Institutes of Health.

M. Michael Sigel
Thomas M. Scotti
Martha A. Wryk
Mantley Dorsey, jun.
Departments of Microbiology and Pathology,
University of Miami School of Medicine and
Virus Diagnostic Laboratory,
Variety Children's Hospital,
Miami, Florida. Aug. 5.

[1] Scotti, T. M., Wryk, M. A., Dorsey, jun., M., and Sigel, M. M. (to be published).
[2] Oliver, J., MacDowell, M., and Tracy, A., *J. Clin. Invest.*, **30**, 1307 (1951).
[3] Grobstein, C., and Dalton, A. J., *J. Exp. Zool.*, **135**, 57 (1957).
[4] Grobstein, C., and Parker, G., *J. Nat. Cancer Inst.*, **20**, 107 (1958).
[5] Murphy, J. B., and Sturm, E., *J. Amer. Med. Assoc.*, **79**, 2159 (1922).
[6] Greene, H. S. N., *Cancer Res.*, **11**, 529 (1951).
[7] Willis, R. A., *Proc. Roy. Soc.*, B, **117**, 400 (1935).
[8] Crouse, G. S., *Anat. Record*, **126**, 369 (1956).

Adaptive Muscular 'Allomorphism'

A new method for quantitatively extracting the sarcoplasm and myofibril proteins from striated skeletal muscle and enabling them to be estimated separately has been described in a recent publication[1]. With the aid of this method, it has been shown (as summarized in Table 1) that various types of atrophy modify more or less drastically the protein composition of the calf muscles in rabbits.

As shown by Table 1, after tenotomy and neurotomy the amounts of total nitrogen, sarcoplasm and myofibril proteins are smaller, but the percentage of stroma proteins is greater than is normally the case. After disuse-atrophy induced with a plaster cast, the total nitrogen content diminished less than after tenotomy or neurotomy, the percentage of myofibril proteins declined and the proportion of sarcoplasm proteins rose. Accordingly, disuse-atrophy reduces selectively the contractile myofibril proteins, an observation I am inclined to interpret as a sign of adaptation to altered working conditions.

I have now completed another series of experiments on rabbits the movements of which were restricted by confinement in a small space. Three groups of adult white rabbits of similar initial age and weight were used as follows. (1) 10 rabbits served as controls and their activity was in no way restricted; (2) 5 rabbits were kept for 6 months in cages having a floor area of 35 cm. × 70 cm. and a height of 35 cm.; (3) 4 rabbits were kept for 3 years in cages of the same type as group 2.

All the rabbits seemed healthy throughout and, except as described above, were exposed to identical experimental conditions. While the contribution of age changes to the effects of restricted activity might have been appreciable in group 3, this is unlikely to be so in group 2.

The total nitrogen and the percentages of protein- and non-protein-nitrogen in the thigh muscles were estimated for each animal as described previously[1]. The results are shown in Table 2.

This shows that the amount of total nitrogen and proportions of stroma- and non-protein-nitrogen

Table 2

Animal no.	Mgm. total nitrogen per gm. muscle tissue	Nitrogen components as percentage of total nitrogen content			
		Myofibril	Sarcoplasm	Stroma	Non-protein
Group 1					
1	32·8	59	26	5	10
2	32·1	58	25	7	10
3	34·0	60	24	6	10
4	32·6	62	23	6	10
5	31·8	57	27	7	10
6	33·1	56	27	6	11
7	32·9	61	23	6	10
8	32·4	60	24	6	11
9	32·7	59	24	6	11
10	33·4	62	22	7	9
Mean	32·8	59	25	6	10
Group 2					
11	33·4	52	31	6	11
12	32·9	52	33	4	10
13	34·1	51	33	6	10
14	32·0	49	34	6	11
15	32·8	53	31	7	10
Mean	33·0	51	32	6	10
Group 3					
16	34·3	40	44	6	11
17	35·2	39	44	6	11
18	32·6	44	41	5	10
19	34·2	41	43	6	10
Mean	34·1	41	43	6	10

Table 1

Treatment	No. of rabbits	Weight loss (per cent)	Total nitrogen content (mgm./gm. muscle tissue)	Nitrogen components as percentage of total nitrogen			
				Myofibril	Sarcoplasm	Stroma	Non-protein
Controls	50	—	32·3±0·2	57±0·6	25±0·5	8±0·1	10±0·1
Denervation	16	33·1	26·0±0·6	50±0·8	24±0·6	16±0·5	11±0·3
Tenotomy	16	32·5	26·4±0·5	53±1·8	26±1·4	12±0·5	11±0·3
Plaster cast	16	21·0	30·4±0·5	48±1·2	29±0·8	11±0·5	12±0·2

remained practically unchanged. In group 3, moreover, the percentage of myofibril nitrogen—which in the controls was more than twice as high as that of sarcoplasm nitrogen—had declined by about one-third, and the percentage of sarcoplasm nitrogen had increased to about the same level as myofibril nitrogen. Changes with the same tendency were observed in group 2.

Since atrophy invariably increases the proportion of stroma in a muscle, and since it remained unchanged here, this shift cannot have been caused by any kind of atrophy. Nor can pathological factors have been involved. But the muscles in group 2, where age changes cannot have occurred, exhibited changes of apparently the same fundamental type as, only of lesser degree than, the changes observed in group 3. However, the possibility that ageing might produce similar changes in animals that have maintained a constant activity-level throughout their lives cannot be ruled out entirely. Yet irrespective of how the variation arises, the composition of the muscle cell can evidently vary greatly from one normal individual to another.

Changes of this type—for which allomorphosis would seem to be an apt term (ἄλλοσ, other; μορφή, shape)—are due to adaptation of the cell in various circumstances, the degree of activity being a causative factor in the case of the muscle cell. Conceivably, other cells in the organism also undergo allomorphosis.

Hitherto the consensus of opinion appears to have been that the cells in a tissue are of fairly constant composition, and that the proportions of the various cell constituents will change greatly only under pathological conditions. But here it has been demonstrated that, at least in muscular tissue, the composition of individual cells may undergo considerable variations even under normal conditions.

Allomorphosis of the muscle cell must clearly be accompanied by changes in its contractile power. A muscle in which the cells contain a sharply reduced proportion of contractile proteins, and concomitantly an increased proportion of sarcoplasm proteins, cannot be as powerful as an unchanged muscle. Accordingly, because the composition of muscle fibres may vary so greatly, the contractile powers of two muscles cannot be compared solely on the basis of the effective areas of the muscle cross-sections.

Einar Helander

Institute of Anatomy,
University of Gothenburg,
Sweden.
July 21.

[1] Helander, E., *Acta Physiol. Scand. Suppl.*, **41**, 141 (1957).

Salt Requirements in the Tropics during Summer

In a recent communication, Dahl[1] has stated that a considerable reduction in quantity of salt intake can be made from the existing levels, without any harm to the body. This may, on the other hand, be of great benefit in reducing the incidence of hypertensive cardiovascular disease. The treatment of hypertension by low salt diet is quite well established, but it was not known before that persons on habitually high salt diet are more prone to essential hypertension and its complications. Dahl has predicted that where salt diet exceeds 5 gm. of sodium per day (that is, 12·5 gm. sodium chloride) incidence of hypertension and its complications will be frequent.

This statement may be true of cold and temperate climates where there is practically no loss of salt in sweat and all the dietary salt is excreted in urine (negligible amounts also in fæces and saliva). In the tropics, on the other hand, excretion of salt in sweat is quite appreciable and is higher in those unacclimatized than in those acclimatized. This is because in acclimatized persons the concentration of salt in sweat is comparatively less, due to the influence of adrenal hormones. Therefore requirement of salt is different for the two. When, after living in a hot climate, a person gets acclimatized to heat, his requirement of salt is also reduced.

Our studies have shown[2] that in an environmental temperature of about 101° F. and relative humidity 54 per cent, acclimatized subjects sweating 3–5 l./day could be kept in salt balance on 6·2 gm./day. The requirement of salt has been found to increase proportionally with rise in dry-bulb temperature of the environment. When the maximum day temperature is about 110° F., the requirement of salt has been found to be about 15 gm. for an acclimatized person working for 8 hr. a day. These results have been supported by observations on ratings working in Indian Navy ships for 8 hr. a day in the engine room, where the dry-bulb temperature of the environments was of the order of 110° F.[3], and no case of salt deficiency was recorded on salt intake of 15 gm. a day. Observations in the textile industry in India[4] have also shown that there is no salt depletion in workers working at temperatures up to 86° F. effective temperature for 8 hr. on a normal salt intake of about 15 gm./day.

It has been also found[5] that the physiological requirement of salt is less than that needed for balancing taste in food. If enough salt is taken to satisfy the palate, there is very little likelihood of salt deficiency occurring in the body.

Low incidence of hypertension in India is not due to low salt intake as suggested by Dahl[1]; but is probably due to heavy losses of salt in sweat. The salt content of the Indian dietary varies from 14 to 24 gm. a day from north to south[5], which is more than that of Western countries, where the diet contains 10–15 gm. salt a day[6].

From the foregoing it can be concluded that about 15 gm. of salt (6 gm. sodium) is quite adequate for acclimatized persons engaged in manual work in the tropics, and that for sedentary persons about 6 gm. salt a day is quite enough.

My thanks are due to Prof. D. S. Kothari, scientific adviser to the Minister of Defence, for his interest in this work and permission to publish this communication.

Mangal Sain Malhotra

Defence Science Laboratory,
Ministry of Defence,
New Delhi, 12.
July 24.

[1] Dahl, L. K., *Nature*, **181**, 989 (1958).
[2] Malhotra, M. S., Sivaraman, R., and Balkrishan, Ministry of Defence, Defence Science Organization (India) Report No. 3/56 (1956).
[3] Malhotra, M. S., and Bhattacharya, M. N., Ministry of Defence, Defence Science Organization (India) Report No. 10/54 (1954).
[4] The Chief Adviser Factories, Ministry of Labour and Employment, Government of India, New Delhi, Report No. 17 (1957).
[5] National Sample Survey Depot of Economic Affairs, Ministry of Finance, Government of India Report No. 1, Table Q (1952).
[6] Leitch, J. N., "Dietetics in Warm Climate" (Harrison and Sons, Ltd., London; 1930).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 13

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Rationalization of the Avenues of Higher Education for Electrical Engineers".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 6 p.m.—"They Were Kafirs" (Colour films with commentary by H.R.H. Prince Peter of Greece).

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the EWELL COUNTY TECHNICAL COLLEGE FARADAY SOCIETY, at the Ewell County Technical College, Reigate Road, Ewell, Surrey), at 7 p.m.—Dr. T. W. Farthing: "The Chemistry and Applications of Beryllium".

Monday, October 13—Tuesday, October 14

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 9 a.m. on Monday and 9.30 a.m. on Tuesday—Symposium on "Texture in Foods".

Tuesday, October 14

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Plant Constituents Meeting.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS (at 6 Buckingham Gate, London, S.W.1), at 2.15 p.m.—Mr. A. E. H. Higgins: "Pest Spraying".

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Mr. D. L. Pratt: "The Antarctic Expedition" (Stevenson Lecture).*

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. K. W. J. Bowen: "Titanium and its Alloys as Materials of Construction for Chemical Plant".

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—"Thermoplastic Pipes" (Open Forum).

Wednesday, October 15

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. D. J. Bell: "Carbohydrate Metabolism".*

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting. Captain F. J. Wylie, R.N.: "Automation in Marine Navigation" (Presidential Address).

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. W. G. Harper and Mr. J. G. D. Beimers: "The Movement of Precipitation Belts as Observed by Radar"; Mr. N. P. Sellick: "Modification of the Structure of a Tropical Cyclone on Traversing a High Plateau".

BRITISH COAL UTILIZATION RESEARCH ASSOCIATION (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Sir Charles Goodeve, F.R.S.: "Carbon—The Key to Metallurgy" (Seventh Coal Science Lecture).

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. Christopher Tietze: "Human Fertility—Statistical Considerations".*

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. J. F. Outram: "Electrical Power Generation and Its Future in Southern England" (Chairman's Address).

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (at "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Role of the Microchemist in Industry" opened by Mr. C. Whalley and Mr. G. Ingram.

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at King's College, Strand, London, W.C.2), at 7 p.m.—Prof. R. L. Wain: "Systemic Fungicides".

Thursday, October 16

ROYAL ANTHROPOLOGICAL INSTITUTE OF GREAT BRITAIN AND IRELAND (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. Herman Lehmann: "Abnormal Hæmoglobins".

UNIVERSITY OF LONDON (at the Beveridge Hall, Senate House, London, W.C.1), at 5.30 p.m.—Sir Edward Salisbury, F.R.S.: "The Influence of Botany on Health and Disease".* (First of eleven lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on October 21, 23, 28, 30, November 18, 20, 25, 27, December 2 and 4.)

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. D. H. Mathews: "Surface Active Agents and Surface Dressing".

CHEMICAL SOCIETY (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Dr. G. Herzberg, F.R.S.: "Spectra of Free Radicals" (Centenary Lecture).

ROYAL AERONAUTICAL SOCIETY, GRADUATES' AND STUDENTS' SECTION (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Major P. L. Teed: "The Fatigue of Aircraft".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Sir Philip Manson-Bahr, C.M.G., D.S.O.: "The March of Tropical Medicine during the Last Fifty Years" (First Manson Oration).

Thursday, October 16—Friday, October 17

BRITISH INTERPLANETARY SOCIETY (in co-operation with the ROYAL AIR FORCE INSTITUTE OF AVIATION MEDICINE, at the Great Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 9.30 a.m. daily—Space Medicine Symposium.

Friday, October 17

INSTITUTE OF RURAL LIFE AT HOME AND OVERSEAS (at Friends' International Centre, 32 Tavistock Square, London, W.C.1), at 1.15 p.m.—The Rt. Hon. the Earl de la Warr, G.B.E.: "Developments in Central Africa".*

BRITISH INSTITUTE OF RADIOLOGY incorporated with the RÖNTGEN SOCIETY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 2 p.m.—Radiobiology Meeting.

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Air Marshall Sir Owen Jones, K.B.E.: "The Mechanical Engineering of Aircraft Mechanisms" (Presidential Address).

Saturday, October 18

BIOCHEMICAL SOCIETY (in the Chemistry Lecture Theatre, Royal College of Science, London, S.W.7), at 2 p.m.—376th Meeting.

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. K. P. Wachsmann: "African Musicians—a Close-up View of Folk-Music in Uganda".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN ORGANIC CHEMISTRY; and an ASSISTANT, Grade "B" (with special interests in botany) IN BIOLOGY at Birkenhead Technical College—The Director of Education, Birkenhead Education Committee, 63 Hamilton Square, Birkenhead (October 15).

ASSISTANT LECTURER (Grade B) IN TELECOMMUNICATIONS AND ELECTRONICS—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (October 17).

PRINCIPAL SCIENTIFIC OFFICER (with a degree, preferably with honours, in horticulture or related science, and experience of horticultural crops, particularly those grown under glass) as Head of a new Horticultural Research Department—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (October 20).

RESEARCH PHYSICIST (preferably with experience in the use of ultra-high vacuum systems or in the chemical physics of surfaces) IN THE DEPARTMENT OF PHYSICS, for which work will involve electrical measurement applied to the study of surface contamination processes on semiconductors—The Professor of Physics, University of Reading, Physics Research Laboratories, Upper Redlands Road, Reading, Berks. (October 24).

TEMPORARY ASSISTANT LECTURER OR TEMPORARY LECTURER (preferably with interests in applied mathematics) IN THE DEPARTMENT OF MATHEMATICS—The Secretary, University College, Gower Street, London, W.C.1 (October 27).

ASSISTANT LECTURER (graduate in chemistry, agricultural chemistry, biochemistry or some similar subject) IN THE DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY, to deal specifically with dairy chemistry and related biochemical topics—The Registrar, Room 29 (O.R.B.), The University, Reading (October 31).

ASSISTANT LECTURER (with a suitable first degree with a qualification in statistics, and interested in the application of statistical techniques to biological or social sciences) IN STATISTICAL THEORY AND EXPERIMENTAL METHOD—The Registrar, Wye College (University of London), near Ashford, Kent (October 31).

LECTURER IN AGRICULTURAL CHEMISTRY (BIOCHEMISTRY); a LECTURER IN AGRICULTURAL CHEMISTRY (SOIL SCIENCE) IN THE DEPARTMENT OF AGRICULTURAL CHEMISTRY, Waite Agricultural Research Institute; and LECTURERS (2) IN PLANT BREEDING AND GENETICS IN THE DEPARTMENT OF AGRONOMY, Waite Agricultural Research Institute, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

LECTURER IN PSYCHOLOGY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

LECTURER OR ASSISTANT LECTURER IN CYTOLOGY in the Department of Genetics—The Registrar, The University, Birmingham 15 (October 31).

PROFESSOR OF INORGANIC AND ANALYTICAL CHEMISTRY at the University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 31).

RESEARCH ASSISTANT (with a first- or second-class honours degree or a research degree in chemistry and an interest in biochemistry), to participate in chemical investigations of fluorine-containing carbohydrates—Dr. P. W. Kent, Department of Biochemistry, South Parks Road, Oxford (October 31).

SCIENTIFIC OFFICER (with a good honours degree in botany, genetics or agricultural botany, and preferably postgraduate training in genetics) IN THE DEPARTMENT OF PLANT BREEDING, to study the

genetics and breeding of the tomato with particular reference to disease resistance—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (October 31).

Physicist (with at least a university honours degree in physics with a minimum of two years research experience) in the Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T., Australia, to join a research team working on the moisture and energy balance of natural surfaces—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 130/329 (November 1).

Junior Lecturer in Physiology—The Registrar, Trinity College, Dublin (November 3).

Senior Lecturer in Anatomy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 7).

Regius Chair of Botany in the University of Aberdeen—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (November 10).

Lecturer (preferably with special qualifications in algebra) in Pure Mathematics—Prof. H. Jones, F.R.S., Mathematics Department, Imperial College of Science and Technology, London, S.W.7 (November 15).

Research Students and Research Fellows in the School of Physics, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 15).

Lecturer in Inorganic and Physical Chemistry at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

Brotherton Chair of Chemical Engineering in the Houldsworth School of Applied Science—The Registrar, The University, Leeds 2 (January 31).

Assistant Lecturer, Grade B (honours graduate in physics and preferably with teaching and/or industrial experience) to teach Physics up to General Certificate of Education, Advanced Level, and National Certificate standard—The Principal, Enfield Technical College, Queensway, Enfield, Middlesex.

Chemist (with a good honours degree in inorganic chemistry or equivalent) in the Geological Survey Department, Government of Tanganyika, for the analysis of rocks, minerals and ores, and the supervision of junior staff in routine analytical work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD. 105/8/09/T.

Computer (with pure and applied mathematics to G.C.E. advanced level) in the Physics Department, for work on rocket and satellite research in the upper atmosphere—The Secretary, University College, Gower Street, London, W.C.1.

Lecturer in the Physics Department, Sunderland Technical College, to teach some branch of applied physics to Higher National Certificate or Diploma in Technology level—The Director of Education, Education Offices, 15 John Street, Sunderland, Co. Durham.

Lecturer (preferably with an interest in geomorphology and/or geology) in Geography in the Training Department—The Warden, Goldsmiths' College (University of London), New Cross, London, S.E.14.

Research Assistant (graduate interested in electrochemistry), to work on a problem connected with the electro-deposition of metals from solutions containing complexing agents—The Head of the Department of Applied Chemistry, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

Scientific Officers (with a first- or second-class honours degree, preferably in physics or electrical engineering), to carry out original research in electronics on a wide variety of interesting problems which arise in nuclear physics and which cannot be solved by present available techniques and equipment—The Senior Recruitment Officer, The Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 2021/34.

Senior Lecturer (with a specialized knowledge of microbiology with particular reference to industrial processes, and actively interested in research) in the Department of Biological Sciences—The Registrar, Bradford Institute of Technology, Bradford 7.

Senior Research Worker (with a Ph.D. degree or equivalent research experience) in the Physics Department, for upper atmospheric research (using Skylark rockets)—The Secretary, University College, Gower Street, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Building Research Station Digest No. 112: Some Recent Work. Pp. 12. (London: H.M. Stationery Office, 1958.) 3*d*. [58

The Education and Training of Student Apprentices in Electrical Engineering: a Report of the Joint Committee on Practical Training in the Electrical Engineering Industry. Pp. 26. (London: Institution of Electrical Engineers, 1958.) 2*s*. [68

Report of the Hydrographer of the Navy for the year 1957. Pp. 18. (H.D. 510.) (London: Admiralty, 1958.) [68

The Utopist Tradition in English Education. By Prof. W. H. G. Armytage. (Sixth Vaughan Memorial Lecture.) Pp. 16. (Doncaster: Doncaster Grammar School, 1958.) 1*s*. 3*d*. [68

World Power Conference. Annual Report 1957. Pp. 20. (London: Central Office of the World Power Conference, 1958.) [68

Cancer Death Rates by Site, Age and Sex, 21 Selected Countries, 1951–1953. By R. A. M. Case and Joyce L. Harley. Pp. xv+64. (London: Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospital, 1958.) [68

Privy Council. Medical Research Council Memorandum No. 36: The Determination of the ABO and Rh(D) Blood Groups for Transfusion. Pp. vi+46. (Revision of War Memorandum No. 9.) (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [68

Forestry Commission. Leaflet No. 6: Honey Fungus. Pp. 9. 6d. net. Leaflet No. 42: Woodpeckers in Woodlands. By C. E. Palmar. Pp. 12. 1*s*. net. Leaflet No. 43: Keithia Disease of *Thuja plicata*. Pp. 5. 1*s*. 3*d*. net. (London: H.M. Stationery Office, 1958.) [88

National Museum of Wales, Cardiff. Paper and Its Uses: Handbook to a Temporary Exhibition, June–December, 1958. Pp. 20+8 plates. (Cardiff: National Museum of Wales, 1958.) 1*s*. [118

University College of Wales, Aberystwyth. Welsh Plant Breeding Station. Report 1950–1956. Pp. 171. 7*s*. 6*d*. Leaflet Series No. 6: The Aberystwyth Strains of Grasses and Clovers. Pp. 18. 2*s*. 6*d*. (Aberystwyth: Welsh Plant Breeding Station, University College of Wales, 1958.) [118

About Vitreosil: a Reference Handbook. Pp. 44. (Wallsend: The Thermal Syndicate, Ltd., 1958.) [138

Current Medical Research: a reprint of the articles in the Report of the Medical Research Council for the year 1956–1957. Pp. v+54. (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [138

London and Home Counties Regional Advisory Council for Higher Technological Education. Bulletin of Special Courses in Higher Technology, including Management Studies and Commerce, 1958–9. Part 1: Autumn Term. Pp. 122. (London: London and Home Counties Regional Advisory Council for Higher Technological Education, 1958.) 3*s*. [138

Report of the City and Guilds of London Institute for the year 1st October, 1956, to 30th September, 1957. Pp. v+118. (London: City and Guilds of London Institute, Gresham College, 1958.) [138

Forestry Commission Bulletin No. 14: Forestry Practice: a Summary of Methods of Establishing Forest Nurseries and Plantations with Advice on other Forestry Questions for Owners, Agents and Foresters. Seventh edition. Pp. vi+93. (London: H.M. Stationery Office, 1958.) 5*s*. 6*d*. net. [138

Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory (period 1957 April 1 to 1958 March 31). Pp. 13. (Herstmonceux: Royal Greenwich Observatory, 1958.) [138

Other Countries

United States Department of Commerce: Coast and Geodetic Survey. Publication 63–1: Gravity Control Measurements in North America. By Donald A. Rice. Pp. 23. 15 cents. Technical Bulletin No. 1: Aerotriangulation Adjustment of Instrument Data by Computational Methods. By William D. Harris. Pp. 1+4. 5 cents. Technical Bulletin N. 2: Tellurometer Traverse Surveys. By Hal P. Demuth. Pp. 1+8. 15 cents. (Washington, D.C.: Government Printing Office, 1958.) [58

Province of Quebec, Canada. Department of Mines: Laboratories Branch. A Chemical Study of the Peats of Quebec. 11: Saint-Hyacinthe Peat Bog, Electoral Districts of Saint-Hyacinthe and Bagot. 12: Saint-Blaise Peat Bog, Electoral District of Saint-Jean. By J. Risi, C.-E. Brunette, R. Cloutier and H. Girard. Pp. ii+32. (P.R. No. 350.) (Quebec: Department of Mines, Laboratories Branch, 1958.) [58

Serving the Caribbean: The Caribbean Commission—What It Is, What It Does. Pp. 24. (Trinidad: Central Secretariat, Caribbean Commission, Kent House, 1958.) [68

The Abstracts Journal: Metallurgy. No. 9, 1957. Translated from the Russian. Pp. 55. Issued bi-monthly. One volume per annum consisting of 6 issues and containing approximately 100 pages per issue. Annual subscription: libraries, institutions and individuals 20 dollars (140*s*.); to members of Co-operating and Sponsoring Societies of *Acta Metallurgica*, 10 dollars (70*s*.). (New York and London: Pergamon Press, 1958.) [68

The Physics of Metals and Metallography, Vol. 4, No. 1, 1957. Translated from the Russian. Pp. 159. Issued bi-monthly. Two volumes per annum consisting of three issues each and containing approximately 150 pages per issue. Annual subscription: libraries, institutions and individuals 30 dollars (210*s*.); to members of Co-operating and Sponsoring Societies of *Acta Metallurgica*, 15 dollars (105*s*.). (New York and London: Pergamon Press, 1958.) [68

National Science Foundation, Washington. Scientific Manpower—1957: Papers of the Sixth Conference on Scientific Manpower. Pp. iii+46. (Washington, D.C.: National Science Foundation, 1958.) [68

Calendar of the New South Wales University of Technology, 1958. Pp. 593. (Kensington, N.S.W.: New South Wales University of Technology, 1958.) [68

Sandia Corporation. Monograph SCR–11: Lectures on Game Theory, Markov Chains and Related Topics. By Prof. Gerald L. Thompson. Pp. 84. Monograph SCR–13: Table of Factors for One-Sided Tolerance Limits for a Normal Distribution. By Donald B. Owen. Pp. 131. (Albuquerque, New Mexico: Technical Information Division, Sandia Corporation, 1958.) [68

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office